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CONSERVATION AND THE CHEMICAL ENGINEER*

SAMUEL P. SADTLER, LL. D.

We have heard much in the last year or two concerning the Conservation of our Natural Resources and we shall, I feel certain, hear much more in the next few years, as the facts elicited from the preliminary studies of the subject come to be understood by the public at large. The importance of the subject will grow correspondingly as the matter is studied by the thoughtful citizen and his appreciation of it will in time be reflected in the activity of the statesmen at Washington in the proposing of remedial measures.

Conservation let us note, however, represents the third stage in the history of the development of Natural Resources.

The first stage is exploration or discovery. This is the era of the prospector and has given us in this country some famous episodes. We need only recall the discovery of gold in California in 1849 and the way in which it operated to attract adventurous spirits from the older parts of our country, or the repetition of the same story with the discovery of the rich gold deposits on the Yukon and at Nome in Alaska.

The first discovery of rich petroleum deposits of western Pennsylvania in the early sixties brought similarly multitudes of prospectors or "wild-catters," as they came to be known locally, and this experience has been repeated also from time to time as great petroleum gushers or powerful gas wells have been reported in various sections of the country resulting in the opening of new fields, as in Ohio, Indiana, Kansas, Texas and Oklahoma.

The second stage is exploitation, when these lavish gifts of nature are worked with a view mainly of increasing production and usually in a wasteful way, with no thought of the exhaustion of the supply.

As illustrations of this stage we need only cite the way in which our coal mines have been worked. In Bulletin 394 of the U. S. Geological Survey (Papers on the Conservation of Mineral Resources) we find the statement that "It has been estimated that the actual loss or waste sustained through coal left in the mines in conducting mining operations amounts to 50 per cent of the quantity produced and marketed." Worse than this, when the Anthracite Coal Waste Commission made its report in 1893 they estimated that "For every ton produced 1½ tons were lost."

One of the most valuable gifts of nature is the natural gas which is associated more or less directly with petroleum. It is a fuel of the greatest value, being nearly pure hydrocarbon in its composition. Yet we find in the same Bulletin of the Geological Survey before referred to the following: "As to the amount of natural gas which is being wasted daily, no accurate statistics have been attempted and the judgment of Dr. I. C. White, State Geologist of West Virginia, may well be accepted to the effect that no less than 1,000,000,000 cubic feet of gas are wasted in the production of oil." This waste Dr. Day of the Geological Survey says "Practically equals the annual consumption of natural gas reported for 1907. This waste should furnish light for half the urban population of the United States."

The exploitation of our once great timber resources and the resulting denudation of great tracts of land and the evils to the soil which have followed in the train of this ruthless waste have been so graphically portrayed by the U. S. Forestry Bureau and others recently that I need not more than allude to this case of reckless extravagance.

It is not my intention, however, to take up this evening the question of the conservation of our natural resources and the absolute need thereof, as so ably developed in recent reports of the "National Conservation Commission," the Forestry Bureau and other official publications, nor yet the part played by the chemist in this Conservation of Natural Resources which has been so ably reviewed by Dr. Bogert in his recent presidential address before the American Chemical Society.

What I would like to do is to indicate that these same three stages of exploitation or discovery, exploitation or effort at production, and finally conservation are to be seen in the history of every great chemical industry and to point out that while it is the part of the chemical engineer to aid in the exploitation step what is still more important is his part in counseling and indicating how the wholesome influence of conservation can be applied so as to broaden and extend the scope of the industry, to maintain and add to its remunerative character and to give it stability and promise of permanence.

*Presidential address, American Institute of Chemical Engineers.

Let us illustrate this view by examples and take first the great petroleum industry to which reference has already been made in speaking of the era of exploitation when the petroleum fields were first outlined by the work of the prospector and driller.

The second stage of exploitation began to draw upon the help of those who were chemical engineers, in fact if not by title. The development of the distilling and refining processes came first. Starting with the old cheese-box still with its circle of heating grates under it, there was a change, following upon the discovery of the "cracking process" as applied to crude oil, to the present form of cylindrical still with its movable cover to regulate the chilling of the vapors during the latter part of the operation. This simple feature in distilling enables the refiners to get 75 per cent or higher of burning oil from the crude petroleum instead of the 45 per cent of a normal fractional distillation, while producing a residuum which can be advantageously distilled for paraffin oils.

The proper control of the acid and alkali treatment of the crude distillates, the change from the old forms of presses for paraffin scale to the modern filter press, the introduction of bone-black filtration for reduced oils and residuums all contributed to develop and expand enormously the several parts of the industry to which they were applied. With these improvements in large scale methods went the inauguration of improved testing and analytical methods so that uniformity of product so essential for sound business development was secured.

Let us turn now to the newer evidence of the work of the chemical engineer in the way of conservation as illustrated in this same industry. The collection and utilization for fuel purposes of the uncondensed gas from the distillation of crude oil is one of the important economies that have been generally adopted. The working up of the sludge-acid and recovery of not only sulphuric acid but of valuable side products is now a feature of the larger refineries. The introduction of clay filtration to improve the quality of the heavier grades of oils is an important advance as well as a step of economy. The production of gas oils from the less valuable crude oils has also become an important industry as these are of great value for gas making and gas enriching. The more thorough utilization of residues is also a feature of recent years. From these residues are now made excellent road oils for the aid of the good roads movement. The petroleum pitch is all utilized also, partly for electric light carbons and partly for fuel purposes. Most promising of all, however, is the result, not as yet fully attained, but most certain of solution in the immediate future, viz., the utilization of crude petroleum of the lesser valuable kinds and residuums in internal combustion engines for the development of power.

A second typical industry is that of coal distillation. We have already spoken of the wastage in the mining of coal. It is not necessary here to speak of the corresponding waste in its utilization as fuel. We will speak solely of the distillation of coal. This treatment may be carried out from either one of two points of view, and the exploitation in each case has been pushed with great energy utilizing all available chemical and engineering skill. The first is the distillation for the manufacture of illuminating gas. While the mechanical side of this process has advanced steadily, particularly after the introduction of regenerative firing and mechanical stoking, the chemical side did not advance so rapidly. While the coal tar is no longer thrown away, unless it be in very isolated localities, the proper chemical utilization of this tar has lagged behind both in this country and in England. On the other hand, the true conservation of this valuable side-product and the development of its possibilities has advanced in a notable degree in Germany, the home of the coal-tar industry. Here the research chemist and the chemical engineer have gone hand in hand in the building up of a great industry, or rather two industries, based upon the utilization of the coal-tar, the manufacture of the coal-tar dye colors and the manufacture of synthetic medical preparations possessing valuable therapeutic characters. Besides these most important and highly developed illustrations of conservation, we have, however, some minor utilizations of coal-tar or products from the same that deserve mention. Thus the manufacture of creosote oils for the preservative treatment of wood, the roofing pitch and tar-paper manufacture and the use of pitch in the briquetting of coal are illustrations of value given to the coal-tar and its products.

The thorough extraction of the ammonia and the impurities like the cyanides from the ammoniacal liquor and the production of commercially valuable products from them is moreover an accomplishment in the way of conservation. The utilization too of the gas carbon for the manufacture of electrode carbons, battery plates and for electric light carbons is another illustration of this work.

The second method of distilling coal is that for the production of coke for metallurgical purposes. This has been developed or more properly exploited to such a degree that, according to the "Mineral Resources of the United States," published by the U. S. Geological Survey, the production of coke for the year 1907 was 40,770,564 tons, of which, however, 35,171,665 tons were produced in beehive ovens. In these, as is well known, only the fixed carbon of the bituminous coal is saved and all volatile constituents including gas, tar and ammonia are absolutely wasted. On the other hand 5,607,899 tons of coke were produced in by-product recovery ovens and the value of the by-products (gas, tar and ammonia) obtained therefrom amounted to $7,548,071. It is easy to reckon from this what the loss was on the 35,171,665 tons of coke made in beehive ovens. In fact, the article on "coal," in Bulletin 394 before referred to, says with reference to this "at the prices which prevailed in 1907, the value

of the by-products wasted in beehive coke ovens was a little over $55,000,000."

But the result achieved by the chemical engineer in the working of this by-product oven represents more than merely saving certain by-products. As we will see on our visit tomorrow to the by-products ovens at Kaighn's Point, Camden, the gas produced can be separated by the perfect control of the method into "poor gas" for fuel purposes and "rich gas" for illuminating purposes so that the highest economy or conservation of values is thereby attained.

Another industry in which the chemical engineer has worked first for the purpose of exploitation and later for conservation of material and values is the starch industry. Starch as we all know is one of the most widely distributed vegetable products and has always played a great part in the world's supply of food. In Europe, it is potato and wheat starch, in the United States it is corn starch, and in tropical countries it is rice, tapioca, sago, etc., that are the important varieties of this cereal food. Not only has the production of starch been developed, however, for food purposes but enormous quantities of the starchy substances serve as the starting point in the fermentation industries. Then we have the use of both starch and its alteration product dextrine in the textile industries and the production of glucose as the product of the hydrolysis of starch, and the manufacture of nitro starch and its utilization in the explosives' industry. All of these industries have attained a high degree of perfection by the application to them of a chemical understanding of the nature of starch and its alteration products and the devising of processes by which the several reaction changes could be carried out with exactness and economy. What that means as applied to one single branch of the starch industry, those of us who had the opportunity on the occasion of our meeting last June to go through the works of the Corn Products Co. at Edgewater, N. J., can appreciate. The glucose production of the United States in 1907 is stated to have been 800,000 tons requiring 40,000,000 bushels of corn as raw material. But besides the production of the solid grape sugar and the liquid glucose for a great variety of uses the separation of the germ of the corn from the starchy portion has made possible the production on a large scale of corn-oil, a product adapted for a wide range of uses, from soap making to the manufacture of rubber substitute.

Turning now to inorganic chemistry for an illustration, we have a splendid example of the work of the chemical engineer in the direction of conservation in the case of the natural and artificial nitrate industry, to which latter the Germans have already given the expressive name of "air-salpeter." The great source of nitrate for forty or more years past has been the deposits on the west coast of South America, furnishing the so-called Chili salpeter or sodium nitrate. This has been drawn upon increasingly until in 1908 the quantity shipped was 1,730,000 tons valued at $87,500,000. But the Chilian deposits are far from being inexhaustible. It is estimated that if the annual consumption increases merely to 50,000 tons and this is to be reasonably expected, from 30 to 40 years will see the practical exhaustion of this supply. So in 1899 Sir Wm. Crookes startled the industrial world by calling attention, in what the newspaper men would call a "scare article," to the nitrogen problem and the necessity of maintaining a supply of nitrogenous plant food if the world's food requirements were to be met. Crookes pointed out the way of relief when he said "the fixation of atmospheric nitrogen is one of the greatest discoveries awaiting the ingenuity of chemists. It is certainly deeply important in its practical bearings on the future welfare and happiness of the civilized races of mankind." The chemical engineer has responded nobly to this demand for conservation of available nitrogenous material by the working out of practical methods for the manufacture of what we called "air-salpeter." It must not be supposed, however, that success was easily obtained. Not only were there the usual experimental difficulties to be overcome but as Prof. Bernthsen has well shown in his address before the London International Congress of Applied Chemistry in May last, there are theoretical difficulties of the most serious kind standing in the road of ready fixation of atmospheric nitrogen and oxygen in the form of nitrogen oxides convertible into nitrates. So it happened that the first large enterprise of this kind, the process of the Atmospheric Products Co. established at Niagara Falls had to be given up as commercially unavailable. This was followed by the Birkeland and Eyde process, started in Norway with the cheapest water power to be found, and this is still in successful operation. A few years later (in 1905), the Schönherr process was worked out by the Badische Anilin and Soda Fabrik, also using Norwegian water power, and still later the Pauling process at Gelsenkirchen near Innsbruck in the Tyrol. Of these the Schönherr process seems to be the most successful and economical. It produces a 40 per cent nitric acid, calcium nitrate, or calcium or sodium nitrite, according as the absorption part of the process is modified. All of the processes mentioned require the cheapest electrical energy, which can only be developed by cheap water power and thus far best developed in Norway. Prof. Bernthsen states, however, that probably within a few years the annual output of calcium nitrate or "air-salpeter" will reach 100,000 tons. As this involves first the fixation of atmospheric nitrogen, and second the use of "white-coal," as water power is some times fancifully called, it is a true lesson in conservation of natural resources, especially as it also enables us to replace a rapidly disappearing natural product.

Closely related to this recently developed inorganic industry of air-salpeter is the slightly older one of calcium carbide and its offshoot the cyanamide or "nitrolime" industry. With the production of calcium car-

bide in the electric furnace in 1892 by Willson, and the publication of Moissan's work on the electric furnace in 1894, sprang into existance a great industry, as the acetylene gas lighting made possible thereby had great advantages. Isolated lighting plants, acetylene lamps for automobiles and carriages, luminous buoys and signals, a new material for lamp-black manufacture and other utilizations all were rapidly developed. The perfecting of the furnaces and the process for this manufacture of carbide enlisted the attention of electrical and chemical engineers and at the present time the world's production of calcium carbide is estimated to be about 200 metric tons per annum, largely in countries like Norway, Italy and Switzerland where cheap water power is available, as well as in the United States at Sault Ste. Marie and elsewhere with similar conditions. This production, however, for the time being outran the demand for carbide for acetylene lighting.

Relief from over-production by finding new outlets and utilizations is always to be preferred to closing of works already in operation, so chemical engineers have found new possibilities for calcium carbide. By far the most important of these is the production from calcium carbide of calcium cyanamide by the action of nitrogen gas, as worked out by Drs. Frank and Caro. We have here an exothermic reaction in which nitrogen is absorbed by the carbide with the production of calcium cyanamide and carbon. This takes place at a temperature of from 800° to 1,000° C., much below that needed for the carbide manufacture. Not only can all the nitrogen of this cyanamide be converted into ammonia by decomposition with steam, but it is gradually decomposed by the chemical and bacteriological constituents of the soil into ammonia, which becomes fixed by the vegetable mold and is so held. The cyanamide is also convertible into calcium cyanide by melting with fluxes, into dicyandiamide for dye-color manufacture, into urea, guanidine and other hitherto relatively expensive organic compounds. The dicyandiamide is already used as a "deterrent" in smokeless powder manufacture, reducing the temperature of the explosion without diminishing explosive force, and the crude calcium cyanamide with certain fluxes under the name of "ferrodur" is employed for case-hardening of iron and steel.

The statement is made that the works for the manufacture of "nitrolime" now in operation or in course of construction have a capacity of 166,000 tons per year.

The illustrations of conservation, whether from the point of view of better utilization of materials, of the production of new and varied products or the recovery of what were waste products could be greatly extended did time allow.

We might refer to the way in which sulphur recovery has been worked out in the alkali industry, or to the manganese recovery in connection with the chlorine production from manganese dioxide, so that "recovered manganese" is today a most valuable article of commerce. Or we might note the saving resulting from the manufacture of reclaimed rubber, a subject which we will have an opportunity of hearing about on Friday from one who has had large experience in this line, and seeing the practical side of in our excursion the same day, but these and similar illustrations of the conservation theme as influenced by the work of the chemical engineer will have to be passed by for the present.

That there are numerous problems as yet unsolved, of equal and possibly greater importance than some of these discussed, will also be conceded by those possessing even a moderate acquaintance with chemical industries.

One of these problems for instance is the recovery of the valuable constituents of the waste liquor of the sulphite wood-pulp process. A German authority states that every liter of this waste liquor contains 120 gms. of organic material as against 10 to 15 gms. of mineral substance. Dr. A. Frank estimated that in 1904 there was wasted in this way in Germany 300 million kilograms of organic material, concerning which we know it has value in several directions. In this country, the sulphite wood-pulp process has also an extensive development and the same waste liquor is run off into our streams.

A somewhat different problem, but one of even greater importance is the loss of valuable metals in smelter smoke and fumes. The American production of bismuth is not over 10,000 lbs. a year and considerable amounts of bismuth and bismuth compounds are imported every year. Yet it is estimated in the forthcoming report of the U. S. Geological Survey for 1908 that 880 lbs. of bismuth per day are being thrown off in the smoke of the great Washoe smelter at Anaconda Montana, and with this also goes copper, lead, zinc, arsenic and other mineral products. One way of saving much of this lost material is pointed out in noting that the replacing of smelting methods by electrolytic methods, possible in some cases, allows these metals to be recovered from the deposited slimes.

In conclusion let us emphasize the fact that our chemical industries need not merely development or exploitation but if they are to continue to flourish as we are drawn more and more into international competition they must have the newest and best results of chemical research applied by the experienced chemical engineer. New and better materials must be sought, better processes evolved, economies effected at all possible stages and waste products carefully looked after. The most successful chemical industries in the world, which show the highest scientific and technical development and which are steadily expanding and throwing out branches are those of the great German chemical companies. Organizations like the Badische Anilin and Soda Fabrik, which have by their employment of both research chemists and chemical engineers, effected industrial revolutions, one after the other, like

the introduction of artificial indigo, the contact sulphuric acid manufacture and last of all the production of air-salpeter or artificial nitric acid and nitrates, are those which reap the rich commercial rewards and for the reason that they have done the work and earned them. The hope of a successful American chemical industry lies in the same direction.

WATER SUPPLY AND TREATMENT FOR POWER PLANT PURPOSES.*

By WILLIAM MILLER BOOTH.

Chemical Engineer, Syracuse, N. Y.

The price of raw material, of fuel, labor conditions and freight rates are important factors to be considered when a new industrial plant is to be built. Less often investigated, yet of primary importance is the presence of a constant supply of good water. If possible two independent sources should be made available.

It is not a large manufacturing concern that requires boilers of 1,000 h.p. capacity. If run 10 hours per day these evaporate approximately 170 tons of water. When condensing engines or turbines are used, from 14 to 17 times as much water is necessary to return the steam again to its original state, or about 2,500 additional tons—in the aggregate more than 9,000 pounds per minute.

The quality of the water is not a matter of indifference, as modern power house apparatus makes exacting demands of the medium passing through and over its parts. It will readily be seen that choice of water requires knowledge of power plant conditions and should not be handled in a haphazard way.

While our population and manufacturing interests constantly increase, available water is decreasing, especially in our small streams that flow through densely settled districts.

Given two sources, the use of that which entails the least cost is naturally considered—the quality is often neglected. Unfortunately water exactly adapted to boiler use is seldom found in nature.

For convenience we classify waters as follows:

AVAILABLE SUPPLIES.

Class—Source.	Contain.	Action in Boilers.
Soft—		
Rain and Snow	Ammonia Salts	Corrosive
Water from granite and quartz rock	Alkali	Negative
Returned	Ammonia	Corrode
Swamps	Organic matter	Corrode
Lakes Large rivers	Calcium and Magnesium Salts	Slight scale
Hard—		
Springs	Lime, magnesia, iron	
Lakes	Sulphates	Scale forming
Small Rivers & Creeks	Chlorides	
Wells	Carbonates	
Saline—		
Sea		
Well	Lime, magnesia,	Scale forming
Mineral Springs	Sulphates, Chlorides & Carbonates, Sodium & Potassium	Corrosive Foam
Alkaline—		
Streams from Western Plains	Sodium, Chlorides, Sulphates and carbonates, Silica, Lime,	Foam
Springs	Magnesia	
Acid—		
Mineral Springs	Hydrogen	
Wells	Sulphide Iron Sulphate	Corrode
Coal Regions	Sulphuric acid	

The first group includes rain and snow waters that are free from scale-forming materials, but which contain organic matter and in the first instance may have a strong acid reaction. The use of such waters is attended with danger from pitting. Harder water should always be mixed with these, or a slight excess of alkali may be added.

Precipiated waters flowing over granite rocks are ideal for boiler use, as enough alkali is absorbed to prevent pitting. Water from wells in the Adirondacks, driven in granite and quartz sand to a depth of sixty feet, was found to possess a hardness varying from .5 to 2 degrees Clark—pure water being unity.

The only distilled water practicable for boiler purposes is that returned from vacuum pans, pumps, engines, turbines, surface condensers and heating systems. Condensed water from turbines containing no oil ought to be ideal for boiler use. We have, however, had an instance of severe corrosion resulting from the use of such water with a proportion of fresh hard water added at each return to the boilers. Returned turbine water should be made slightly alkaline. We believe that the open heater and hot well should be much more generally used and that a good oil separator is indispensable in any large plant. Anxious to keep his apparatus well lubricated the engineer often uses an excess of oil which makes it difficult to utilize the condensed water. A large amount of energy escapes daily from many plants through heated water that runs to waste, in addition to the loss of soft, scale-free boiler water. Many engineers suffer from oil at the surface of the water in the boiler; the gauge glass

*A paper presented at the Twenty-Ninth Annual Convention of the American Water Works Association.

showing this condition quickly. If mineral oil is used in the power plant we do not worry about the presence of a small quantity in the boiler, but prefer to keep it out.

Another class of soft waters is found in the lowlands of the coast. A heavy rainfall with finely divided organic matter and heat, combine to charge standing water with organic matter which may be acid in character. Boilers using such water suffer from corrosion and require alkali.

The waters of some lakes, large rivers and a few deep wells deposit little scale and may be termed "soft." Arbitrarily we fix the hardness under 3° Clark. Such waters contain suspended particles, sand, clay, leaves and dissolved organic matter, the quantity of these varying greatly during different seasons. These require considerable blowing down at the boiler. Water of this character is improved by sedimentation in large tanks followed by upward filtration through coarse material, as sand, coke breese or excelsior.

We insist that water for boiler purposes shall be clean. Sewage laden lake or river water carries grease which accumulates upon the headers of water tube boilers and corrodes the tubes and shells of tubular boilers. Our clients are much annoyed by such water. We recommend sedimentation, upward filtration and legal proceedings against the corporation or individual contaminating the stream. This applies particularly to abattoirs, rendering plants, woolen mills and cities. As a last resort we recommend chemical precipitation and filtration.

HARD WATERS.

A large proportion of our water supply is scale forming. If ten grains of this material per gallon are present nearly 140 pounds of sludge and scale will concentrate, in a 24-hour, 1,000 h.p. plant. This badly interferes with the operation of the boiler as a steam producer. In many samples of water, carbonates vary from 3 to 15 grains per gallon and sulphates from a trace to 120 grains per gallon. What these compounds are and how they are formed will not be discussed here.

Organically pure but hard sources of supply are used by many cities and towns to the disadvantage of manufacturers. We have suggested in a previous paper that large operators should combine to manufacture soft water for their common use. Water companies might soften supplies furnished certain districts. We believe that scale-free, clean water is worth ten cents per 1,000 gallons. It usually costs less than three cents to soften this.

Many manufacturers drill deep wells to provide drinking water and to serve as an auxiliary supply. We suggest consultation with a practical geologist before putting a large amount of money into such an enterprise.

Having been fortunate enough to obtain water this may be of any class mentioned in the table. For power plant purposes heavily charged mineral waters are to be avoided. We present an analysis of a well water that is useless for boiler purposes:

GRAINS PER U. S. GALLON
COMBINED.

Sodium chloride	1.252
Calcium carbonate	16.959
Calcium sulphate	87.462
Magnesium carbonate	.000
Magnesium sulphate	15.555
Magnesium chloride	.000

Calcium and magnesium carbonates and calcium sulphate are scale producers. Chloride of magnesium corrodes metal and sodium chloride accumulates on all semi-heated surfaces. For boiler purposes we have not been troubled by the precipitation of iron found in natural waters. If water from a well contains all of these forms of impurity in any considerable quantity it should not be used for power purposes.

Those who drill wells should take samples of the strata and water encountered. Analysis of these will show what veins of the supply are to be avoided and cased out. As an example of the vicissitudes of well drilling we instance the following:

To 100 ft.—small quantity, soft water.
100 to 600 ft. no water.
At 600 ft. salt; 300 grains per gallon, sodium, magnesium and calcium chlorides, with carbonates and sulphates.
At 900 ft. salt.
900 to 1,200 ft. no water.
1,270 ft. granite rock, no water; drilling suspended.

SALINE WATERS.

Few waters are free from chlorides. Common salt is not considered scale forming, although large quantities are not easily handled, while the chlorides of calcium and magnesium are very objectionable in a boiler. We have found no trace of chlorine in an Adirondack camp supply drawn from a small stream. Water from Oneida Lake, N. Y., did not contain one part of chlorine per million. This lake is 28 miles long and several miles broad. The sample was taken through the ice in the winter.

Wells, springs and streams in the Salina group contain chlorides varying in our experience from traces—to 600 grains of salt per gallon. The quantity of chlorine at various localities in central New York westward is as follows:

Canajoharie, 570 ft. under surface.	6 grains
Utica, 600 ft. under surface.....	300 grains
Oneida, 100 ft. under surface.....	30 grains
Syracuse, 50 ft. under surface...	360 grains
Cayuga Lake	2 grains
Seneca Lake	2 grains
Akron, Ohio, 60 ft. under surface.	2 grains

Waters in this belt contain also sulphates and carbonates of calcium, magnesium and sodium, the water varying in hardness from 5° to 80° Clark. Such water is found in Ohio, Ontario, Indiana and Michigan. These ground waters generally need treatment. Shale

waters if in higher altitudes are very good with an average hardness of 6° Clark.

We have no remedy to offer for heavily charged saline waters. Evaporation results in choking boilers and condensers. Wells on opposite sides of the New York Central tracks at Oneida, N. Y., about 150 feet apart contain respectively 9 and 30 grains of salt per gallon, the first being 96 feet, the second 106 feet in depth. Both waters are used successfully, the first without, the second with softening apparatus. Well water containing one and one-half ounces of salt per gallon and scale forming cannot be used by Syracuse manufacturers to good advantage.

ALKALINE WATERS.

Some waters contain carbonate, chloride and sulphate of soda and potash with perhaps chlorides of calcium and magnesium.

This is particularly true of waters of the western plains and lakes. As an extreme instance we submit the following analysis of a water sent us from a California lake:

GRAINS PER U. S. GALLON.	
Silica	14.35
Alumina	trace
Oxide of iron	.00
Calcium carbonate	trace
Magnesium carbonate	.00
Potassium chloride	93.56
Sodium chloride	2,754.30
Sodium sulphate	610.50
Sodium carbonate	2,573.10
Acid carbonate of soda	248.50

This is a representative of very bad alkali water, which could not be used for technical purposes.

Our practical experience with alkaline waters has been confined to those artificially produced in eastern plants by the softening process. If a boiler is clean we find it almost impossible by adding alkali to produce foaming. This has been proved with an excess of soda ash amounting to 50 grains per gallon.

ACID WATERS.

Water from expensive wells sometimes tastes and smells of hydrogen sulphide. If at all strong engineers will usually not allow such water in their boilers. We believe that, should circumstances warrant the outlay, a heavily charged sulphur water could be successfully prepared for boiler or other industrial use.

Water from the mining districts often contains sulphate of iron. We consider this dangerous water and suggest treatment before use.

Some waters contain free sulphuric acid. Sometimes such water is supplied naturally but generally this is found in sludge from acid plants, coal washers, or refineries. No more dangerous material can find its way into the boiler.

A sample of scale from boilers in a Pennsylvania steel works was practically pure oxide of iron, the result of an acid supply.

We devote the remainder of this article to methods of handling scale-forming, saline, and alkaline waters.

Three principal uses of boilers afford a natural division as follows: marine, locomotive, stationary.

Marine boilers are generally supplied on coast-wise steamers, tugs and harbor craft, with soft water that is obtained at one of the ports at which the vessel touches. As many of the engine cylinders are run without oil the returned water is used again. Trans-Atlantic steam ships are supplied with surface condensers and complete distilling outfits of expensive design and the softened water is used again.

Locomotive boilers represent an enormous horse power and need the best water obtainable. Hard water only can be found on many lines. Sometimes a soft supply is found at one end of a division and hard water at the other. Alternate use keeps the boiler free from scale. Starting and stopping and generally in motion, the alkaline content of a locomotive boiler water must be kept low. With sludge, serious foaming may result through the use of an excess of softening agent. This subject demands immediate attention on the part of all railroads. Western systems have done more in this respect than those in the east.

Our experience with stationary boilers has been divided between shell and water tube types. Methods of water treatment apply in a general way to either, although many disadvantages of hard and muddy water are overcome in water tube boilers.

Engineers in charge of steam plants are usually ignorant of the principles of water purification. This is only partially their fault, as literature for their education has only recently been available. There are many plants the boilers of which cannot be operated a single week without a deposit of scale serious in character and quantity. The most easily procured remedy has been the "compound" furnished at an inflated cost. The introduction of the softening plant has widely advertised the fact that lime, soda ash, caustic soda and tri-sodium phosphate are cheap and efficient scale removers. Many an engineer spends the Sabbath day hammering scale only to repeat the operation the Sunday following. This is usually unnecessary, as proper chemical treatment will remove the scale formed and prevent the deposit of more.

The actual cost during the past seven months to keep boilers clean in a 2,000-h.p., 24-hour plant has been less than $15, the hardness of the water being 5° Clark. Caustic soda and soda ash have been used in slight excess.

Ideal conditions favor the installation of a standard softening system. We feel, however, that prejudice is so great that it will take at least five years to make these plants popular with engineers who have in many instances received gratuities from compound salesmen, or with managers who cannot see an adequate return for the investment.

We now turn to methods of treatment.

While waiting for a better understanding of the correct thing to do when annoyed by hard water we have adopted the following method which is now used in many plants. Analysis is made of the water supply

or supplies; of the water from the heater, from each boiler and from the hot well. In this way we find remarkable conditions. The hardest water that has come to our notice was taken from three water tube boilers:

1. 43° Clark.
2. 85° Clark.
3. 382° Clark.

It is not unusual to find alkalies and scale-forming ingredients concentrated in the boiler water. If the supply has a hardness of 10° Clark, the internal water may have a hardness of twenty, thirty or even forty degrees.

Great stress has been laid on the removal of carbonates by heaters. We find carbonates in most boiler waters and believe that the best heaters may remove 50 to 75 per cent of these. The water circulates too rapidly to favor their deposit and the dissolved gases are occluded under pressure. We present the analysis of samples of water where a live stream purifier is used. (Table 8.) The concentration of chemical salts in the presence of organic matter may cause serious corrosion. We believe that sulphates of calcium and magnesium may produce or aid in producing the holes that are eaten in feed pipes and flues, heretfore credited to chloride of magnesium but which we find may occur when none of this chemical is present. Further investigation must be made to determine the exact cause of the foregoing results.

Having proved the presence of concentrated salts in a set of boilers, we suggest to the engineer that he shall "blow down" once in four hours or two or three times per day from one-half to two inches of water. This form of treatment some engineers will not adopt, stating that it will strain their boilers to blow them under full steam pressure; others do this regularly. We have a plant of this kind in mind where there are two 200-h.p. shell boilers that have been blown down under full head of steam perhaps two inches each afternoon for four years with no injurious results.

The scale-forming materials separate in the boiler, the decomposing carbonates rising to the top and forming a light scum, which accumulates on the upper tubes, while the sulphates and precipitating carbonates form a dense, heavy scale on the shell and lower tubes of the boiler. We believe that it is a very good plan to blow out the accumulated sediment in the morning and in the evening, and that considerable scale may be removed from the water surface while the boiler is under full steam pressure, by opening suitable cocks.

Boilers are set in peculiar ways either accidentally or through ignorance. We have found boilers with the blow-off at the rear no less than 4 inches higher than the floor of the boiler at the front. In some boilers the blow-off is found 3 or 4 inches above the lowest point of the shell, and we find engineers who blow their boilers but once per week, putting in from one to five gallons of compound Monday morning, and making this last the entire week, blowing it out at the close of the working day Saturday. Severe scaling or severe corrosion may result from the lack of use of the blow-off valves. If we are running a boiler or a battery of boilers using hard water we would use the blow-off at least three times during the 24 hours. Lack of attention regarding falling scale and accumulating sludge may result in a bad bag or blister of the crown sheet.

THE PRESCRIPTION.

If the engineer finds that he cannot handle the sludge through the blow-off valve, (and this the chemist can determine usually in advance) a mixture of alkali should be used in the boiler. This is added with the feed water drop by drop. The quantity bears but little relation to that prescribed for the same water in a water softening outfit. For instance, the prescription may call for five pounds of soda ash and two pounds of caustic soda per thousand gallons of raw water. If this is placed in the boiler in exact proportion to the number of thousand gallons used the chances are that very severe foaming will result during the coming three days. We prefer to divide the prescription by at least five and then test samples of water taken from the boilers under treatment, making a careful analysis of such treated water. In this way we are able to determine the quantity and amount of chemicals absorbed and those left in solution, also the quantity and amount of scaling material removed, and that left in the water.

The scale that accumulates on the tubes and shell is often useful in determining the kind of treatment that a boiler needs, but this scale may differ materially in composition at different points in the boiler.

The use of boiler compounds containing tannin is determined by black scale which is a dye formed by the union of tannin and iron at the expense of the boiler itself. We discourage the use of such compounds.

Objections are raised by some engineers to the use of soda ash in boilers. We have yet to find a single instance where soda ash is used in moderate quantities—even to 50 grains per gallon in excess—has injured a boiler shell or tubes, and would much prefer the use of a small quantity of this material in a boiler water to the use of rain or distilled water, both of which have a highly corrosive effect on iron. Again, some engineers state that soda ash injures gaskets.

During two seasons we have tried this out in a 2,000-h.p. plant where the steam is used for heating houses and office buildings, and although expensive and complicated steam traps, meters, and gaskets are used throughout the system, we have failed to experience any difficulty whatever from this method of treatment.

Having reckoned the amount of caustic lime required to remove carbonates from the water for internal treatment we use a fraction of its equivalent of caustic soda. With carbonic acid this material is changed to sodium carbonate and if sulphates are pres-

ent a second reaction takes place. A much smaller proportion of soda ash is required than when lime and soda ash are used.

On account of this double action, we believe that caustic soda should be used much more generally in water, as it is more easily handled than lime and as, further, a concentrated solution can be made. After the preparation has been applied and an analysis of the water has been made, it is not difficult to see what changes are necessary. These should be applied at once. Any form of exact treatment for boiler water within or without the boiler, demands the services of an experienced chemist and an interested engineer. An excellent water softening apparatus failed because the engineer in charge would not give it fair treatment.

Those in charge of power plants are usually anxious to learn some of the principles involved in water purification. It has been our practice to supply a regular outfit for their use. This includes the following:

1 Glass burette,—funnel and filter papers.
1 bottle phenolphthalein solution.
1 bottle methyl orange solution.
1 bottle silver nitrate solution.

1 quart of soap solution with the formula for making up more, and sometimes a bottle of standard decinormal hydrochloric acid. This apparatus is purchased by the power plant owner, and placed in the engine room. We have been told by one engineer that he would not take one hundred dollars for the little kit of tools provided to determine the processes going on in the boiler water. The number of tests that these men will make and the care and accuracy exercised in making them are surprising. We have gotten up a printed form for permanent records, such being turned in at the office each day.

WATER SOFTENING PLANTS.

As there are now several forms of water softening apparatus on the market that are entirely efficient the power plant manager and operator have no excuse for using a scale-charged water. With a thousand horsepower or a larger plant and with water about 10° in hardness a water softening outfit can be shown to be an investment paying more than 10 per cent on its cost and operating expenses. In some instances this percentage may be raised to a point where the whole apparatus will pay for itself within two or three years. There is great prejudice on the part of engineers to the use of softened water, and we have found men who have put in expensive plants of this sort who are not operating them. The reason being that "they're too much bother."

Considering the cost of extra fuel, flues, the cost of opening the boilers, removing scale and poor steaming capacity a scale-free water is a valuable investment. We find plants that are operating with boilers that have not been opened for months, and that are found in a scale-free conditions, the water being of a hardness of about 20° Clark per U. S. gallon. Originally we were not sure of the action of caustic lime and soda ash on concrete tanks, but believe that with a carefully constructed tank of this kind no danger whatever will result through the action of the alkali on the cement mass. A tank has been in use for this purpose for three years and is still in first-class condition.

The ideal chemical for softening water is not now available. Calcium, magnesium and the sulphate radical should be removed. Excessive foaming would be avoided and softened water would approximate distilled water in purity.

SUMMARY.

In conclusion we wish to call atention to the following:

To locate at least one constant supply of good boiler water is an important duty of the engineer who lays out a new plant—if more than one supply can be made available every reasonable effort should be made to secure the second.

Water for boiler purposes should be clean and scale-free. Filtration and softening will produce both conditions even though the supply is bad, sodium chloride and alkaline waters excepted.

Money put into a "well" enterprise is a business venture with uncertain results, but is recommended if conditions warrant the expense.

Water companies should give technical aid to large power users if difficulty is experienced with the water furnished; that delivered to manufacturing districts might be softened before distribution.

Resident engineers should be compelled to make daily reports of the condition of the water from their boilers and a competent chemist should be employed in connection with every large power plant.

This association could to good advantage appoint a committee to report on technical methods of water analysis with the official adoption of a provisional method to be used throughout the United States. This branch of practical chemistry is now of great importance to mechanical engineers.

VARIOUS TYPES OF WATERS.

No. 1.—Artesian well; useless for any commercial purpose, found 600 ft. under the surface in central New York.

GRAINS PER U. S. GALLON.

Calcium carbonate	9.373
Calcium sulphate	.543
Calcium chloride	30.302
Nitrogen pentoxide	.000
Magnesium carbonate	.030
Magnesium sulphate	.000
Magnesium chloride	32.333
Sodium Chloride	293.350
Oxides of iron and aluminum	.542
Silica	.600
Total solids	376.975

No. 2.—A well water in the salt belt containing oil. Has not been used successfully in a tubular boiler.

GRAINS PER U. S. GALLON.	
Calcium carbonate	12.48
Magnesium carbonate	.00
Calcium sulphate	4.59
Magnesium sulphate	.00
Magnesium chloride	5.18
Sodium chloride	32.40
Oxides of iron and aluminum	.025
Silica	.23
Nitrogen pentoxide	.20
Organic and mineral oil	9.64
Total solids	64.02

No. 3.—Water that produces a very hard scale that is very corrosive, eating out feed pipes in a few months.

GRAINS PER U. S. GALLON.	
Sodium chloride	1.76
Calcium sulphate	23.45
Calcium carbonate	8.94
Magnesium sulphate	11.00
Total	45.15

No. 4.—A very corrosive water, scaling also.

GRAINS PER U. S. GALLON.	
Calcium carbonate	6.140
Calcium sulphate	77.543
Magnesium carbonate	.000
Magnesium sulphate	.000
Sodium chloride	20.307
Sodium sulphate	3.450
Silica	.257
Nitrogen pentoxide	.212
Oxides of iron and aluminum	.616
Organic and volatile	23.815
Total	132.480

No. 5.—Water saturated with gypsum, which is successfully treated in a horizontal boiler, through the use of soda ash, and which scales badly during one week without treatment.

GRAINS PER U. S. GALLON.	
Sodium chloride	.753
Sulphur trioxide	53.274
Magnesium oxide	4.869
Calcium oxide	34.637
Alkalinity	8.60
Hardness, Clark	58.50°

No. 6.—Representative of water from many lakes in New York state. A spongy scale is produced, which is difficult to remove, but considerable time is required to deposit enough to do damage.

GRAINS PER U. S. GALLON.	
Calcium carbonate	4.046
Magnesium carbonate	.466
Calcium sulphate	.538
Magnesium sulphate	.660
Chlorine	.100
N_2O_5	.063

No. 7.—Water producing a flint-like scale in water tube boilers.

GRAINS PER U. S. GALLON.	
Calcium sulphate	17.33
Calcium carbonate	8.36
Magnesium carbonate	4.89
Sodium chloride	.74
Organic and volatile	8.18
Total	39.50

No. 8.—Removal of scale forming matter in a line steam heater and softener

	River.	Hot Well.	Filter.
Total solids	26.410	20.117	18.363
Alkalinity	6.37	3.86	1.17
Calcic oxide	5.395	4.678	3.456
Magnesic oxide	1.128	.701	.000
Sulphur trioxide	2.800	2.105	1.631
Chlorine	4.950	5.731	5.613

TRYING TO ESTABLISH INDUSTRY.

In a recent report on the manufactures of Brazil, Consul-General Anderson says:

One of the most notable features of the industrial situation in Brazil is that while it seems to have one of the greatest deposits of fairly high-grade iron ore in the world, if not actually the greatest, only about 3.5 per cent of its industries are such as relate to iron working in any form, and such establishments, as a matter of fact, work imported materials. This condition is due not only to a lack of fuel, as indicated, but also to lack of talent in the iron-working industries, such attempts as have been made to establish such industries in the past, even with the aid of the government, having been expensive experiments. It is, therefore, of more than passing importance to Brazil that the government has undertaken to secure the investment of foreign capital and the aid of foreign talent in the establishment of the iron-working industry in the country, an undertaking which is now in the course of development.

ASPHALT.

The natural asphalt imported from Trinidad and Bermudez supplies a large part of the paving material used in the United States. Oil asphalt, when properly made in the process of distillation of asphaltic oils, is free from earthy substances commonly carried by natural asphalt and is brought to the eastern markets in large quantities. Bituminous rock is used chiefly for paving. The other important uses of asphalt products are in waterproofing metals, papers, and fabrics, in roofing, electric installations, wood preservation, brick and wood block filling, concrete construction, coal briquetting, adulterating hard rubber, etc. Gilsonite and grahamite are also especially adaptable for use in the manufacture of japans, paints and varnishes.

THE PLANT.

VACUUM EVAPORATION.[1]

By P. B. SADTLER

Chemical Engineer, Swenson Evaporator Co., Chicago

(Concluded from November Issue.)

CALCULATION FOR HEATING SURFACES.

The amount of heating surface necessary in an evaporator to be used for any given class of work depends on the following factors: (1) The amount of water to be evaporated, (2) the number of effects desired, (3) the initial steam pressure, (4) the boiling points of the solution to be evaporated, (5) the evaporative factor for a given type of machine, and for a given solution to be evaporated.

In calculating the amount of water to be evaporated, it is merely necessary to obtain from tables or analysis, the per cent of solids in the dilute and the concentrated liquor. From this we can obtain the amount of water to be evaporated. When the number of effects in which the evaporation is to be done is determined, a calculation should be made of the water evaporated in each effect and from that, what the concentration should be maintained at, in each effect. When these concentrations are known the corresponding boiling points should be found from a good table of boiling points or by experiment, or a curve such as shown in Fig. 3 for certain grades of caustic soda washings may be used. The *degrees of excess boiling* temperature is the total of each of these boiling points less 212° F. In other words, if the boiling points in three effects of a triple effect are respectively 214°, 220°, and 236°, the excess boiling temperature is (214—212) + (220—212) + (236—212) = 34°.

From the steam tables of pressure and temperature the *total temperature range* should be found. Or it will be found very useful to use a curve as shown in Fig. 4 where the pressures and temperatures are plotted. Readings from such a plot compare favorably in accuracy with actual steam gauge readings on the evaporator. This temperature gauge then equals the temperature corresponding to initial steam pressure corresponding to vacuum maintained in the last effect.

The *evaporative factor* is a constant quantity. The total temperature range less the excess boiling is the *effective range*. This divided by the number of effects equals the *average effect difference*. The evaporative factor is derived from experience and from operative tests on the type of apparatus best adapted and on the given class of liquor to be evaporated. Probably the same factor would hold, for instance, on all submerged tube evaporators of the general type of those under discussion and would hold for either caustic soda solutions or carbonate of soda solutions, scaling conditions, etc., being otherwise the same. In fact the same constant quantity could be used, and has been used, in designing evaporators for a large range of inorganic chemical solutions, such as sodium chloride, sodium hydrate, sodium carbonate, sodium sulphate, sodium phosphate, sodium acid phosphate, sodium thiosulphate, potassium chloride, potassium hydrate, ferrous sulphate, calcium acetate, etc. However, in case of tannic acid, sugar, glucose, glycerine, black liquor, or resinate of soda, packing-house tank water, garbage tank water, etc., somewhat different conditions obtain and the factor varies. The factor also differs slightly for different materials for the heating surface, that for copper or aluminum being distinctly higher than that for iron.

To specify the units on which this factor is generally based we might say that it is expressed as gallons of water evaporated per square foot of heating surface per degree difference in temperature per hour.

If C = evaporated factor,
E = average effect difference,
W = gallons evaporated,
T = time in hours during which evaporation proceeds,
S = square feet of heating surface,

$$C = \frac{W}{E + T \times S}.$$

Hence, if we find from experience or trial tests the value of C and we calculate E and W, as explained above, it is easy to obtain the required heating surface.

The successful designing of an evaporator is dependent first on the recognition of certain chemical and physical facts relating to the substance to be evaporated; second, on whether or not due regard is paid to certain thermal and thermo-dynamic principles involved; and third, on certain mechanical features that arise in the construction. It is not to be supposed that either an engineer, familiar with the best boiler practice, or a chemist, familiar with laboratory or open-pan evaporation in the works, could successfully design a multiple-effect evaporator. But certain facts in regard to design should certainly aid either a chemist or engineer in procuring the proper design or making a purchase.

As the principal purpose of an evaporator is to concentrate a solution of some sort, it will be readily seen that the chemical and physical laws governing concen-

[1] From the *Journal of Industrial and Engineering Chemistry*.

trated solutions will be of importance. These are only known qualitatively and the quantitative laws which govern the chemistry of dilute solutions are inapplicable.

As most measurements of the concentration of solutions in the works are made with a hydrometer we generally speak of concentrating between certain limits in degrees, Baumé, Twaddell, Brix, salinometer, or specific gravity. It is, therefore, necessary to obtain or devise tables or curves showing the relation of these units of concentration with the percentage of solid matter in solution. The purpose of this is

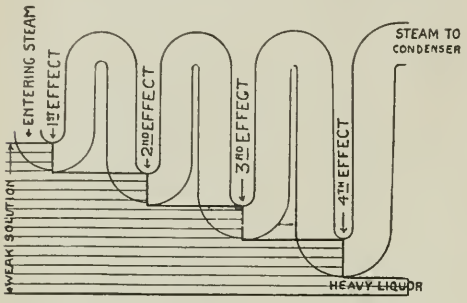


Fig. 1.

to obtain accurate information as to the actual amount of water that is going to be evaporated in a unit of time. This is especially important in cases where the vapor arising from the solution is the source of heat in the succeeding effect of the evaporator.

Of equal or greater importance, is a table or curve for a given solution which shall accurately show the relation between the boiling point of the solution and its concentration. It has been shown above, that the boiling point of a solution at any period of its progress through the evaporator has a direct bearing upon the size of the evaporator. A boiling point curve is generally obtained by taking simultaneous readings upon a hydrometer and thermometer, while boiling a solution actively under atmospheric conditions. This may best be accomplished in a laboratory where accurate means of determination are provided. After this curve is obtained a correction should be made for temperature at boiling to bring the hydrometer readings to the same temperature standard.

In cases where a substance is intended to precipitate from solution, during the process of evaporation, there should be used in conjunction with the above table also a table of solubilities of the substance at different temperatures.

The thermodynamic data necessary consist of the regular steam engineer's tables, showing the relations between temperature, pressure, heat of liquid, heat of vaporization, etc.

There are other chemical and physical data of which account must be taken in designing. The more information obtainable in regard to possible incrustation and scaling of heating surface, the clearer will be the idea as to what mechanical features to introduce for the removal of scale and as to what excess capacity to allow for this contingency. As in boiler practice, one of the greatest sources of annoyance is the deposition of gypsum on the tubes. This annoyance is encountered in the salt industry especially; on account of the peculiar solubility relation of gypsum, it is found more expedient to evaporate at low temperature with large heating surface, thus minimizing the scale. Another similar case is that of soda washings in pulp mills, where cooking liquor is evaporated for soda recovery. If the lime used in the course of the process is high in silica and alumina, these find their way to the evaporator and deposit in a dense fibrous scale. If such possibilities as these are to arise, it is found expedient to have the heating surface in excess of the calculated area and easily removable from the evaporator for cleaning purposes. Moreover, it should be removable where corrosion is expected. There are some chemical solutions which corrode iron at the higher temperatures but are inactive at lower temperatures. In these cases the heating surface bears the brunt of the destruction in the evaporator.

Another important question is, as to the nature of a solution's activity under boiling conditions. In other words, does the boiling solution tend toward entrainment or foaming, or spattering? These points

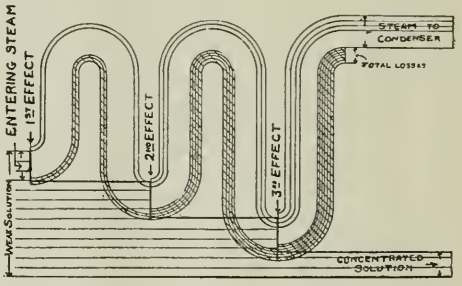


Fig. 2.

must be known beforehand, as they decidedly influence the proportioning of the evaporator.

PROPERTIES OF LIQUIDS AS AFFECTING CONSTRUCTION.

In some industries the multiple-effect evaporator is among the largest and most expensive of the installations in the factory. Where a large evaporator is to be built for constant use, great attention should be paid to details of its design and construction. The liquids commonly evaporated in any quantity can be divided into two classes: those that foam on boiling and those that do not. It may be said in general that a liquor that entrains (or sprays and passes over with its vapor) does not foam, and a foaming liquor does not entrain. Also it is noticeable that solutions of alkaline reaction tend to foam while those of acid reaction tend to entrain. Most sugar juices and glucose come under the latter class. To provide against losses due to entrainment in an evaporator there are to

be mentioned such methods as the use of baffle plates, catchalls, and high-vapor dome. The so-called film evaporators are subject to the difficulty in this respect that the vapor space allowed is invariably small and from the time a portion of the vapor leaves the boiling solution it carries with it a large amount of spray in suspension in its rapid passage through tortuous channels of small cross-section. The simpler types of evaporator whose construction is more like that of a tank are open to the objection often, that the vapor is drawn off from a dome directly over the boiling surface. In these simpler types of evaporators it can

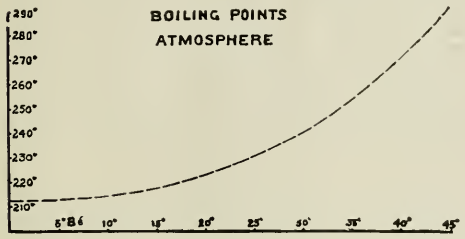


Fig. 3.

be arranged easily to have the sectional area large enough to make the rising of the vapor slow and the height of the dome sufficient to cause practically all the entrainment to drop back. In order not to cause any inversion or possible discoloration in the sugar juices it has been found advisable to have as little as possible of the juice in actual transit through the apparatus. This is accomplished by two principal methods: one by having a rather shallow bank of tubes in which the tubes are packed in the tube sheets as closely together as possible; another by spraying the juice over the heating surface, collecting it underneath and pumping it back again to the spray. This latter method rather subjects the juice to loss from entrainment, unless the vapor dome is extremely high.

In dealing with soda solutions the problems arising are of a very different nature from those in sugar work. Under the head of soda solutions we may include, among other important cases, the evaporation of sodium carbonate, sodium phosphate, pure caustic soda and caustic soda containing brine (electrolytic), black liquor (pulp-mill), mercerizing soda, etc. Except in the case of the more concentrated liquor of the last effect these are all more or less foamy when boiling. The use of baffle plates alone does not accomplish the prevention of loss when foaming takes place. It has been found that the only sure and efficient way to deal with foam, that is to cause it to subside, is to break the individual bubbles by application of heat. Hence the evaporator should be built in such a way that the heating surface is in a high bank above the level of the liquor evaporating. On operating the apparatus it may easily be found by trial what is the proper level of liquid shown in the gauge glass to prevent the foam from rising much above the top of the tubes and yet keep the tubes covered. About the most difficult liquors to handle in this respect are those in pulp-mills of mercerizing plants. In these cases it is necessary to have the heating tube bank almost half the height of the evaporator.

In salt industries there are two main difficulties which have to be met by the designer of an evaporator: first, the salt has to be removed from the apparatus constantly as it precipitates from solution; second, scale that deposits upon the heating surface has to be removed periodically. In order to render the removal of precipitated salt simple and rapid it has been found best to construct the evaporator with a hopper-shaped bottom having either one or two hoppers leading through a valve at their lowest point into a receiver where the salt is separated by draining through a false bottom. Another method consists in precipitating the salt continuously down a barometric leg under the evaporator, draining it and conveying it from the bottom by a closed elevator. This latter method is generally most efficient when working on a very large scale. In salt evaporation work, shut-downs are frequently necessary every day because of the constant deposit of gypsum upon the heating surface. This happens to such an extent that the evaporative capacity of the apparatus is reduced to a point where it no longer pays to operate. Ready means of access should be provided so that the heating surface may be thoroughly cleaned, or arrangements should be made for

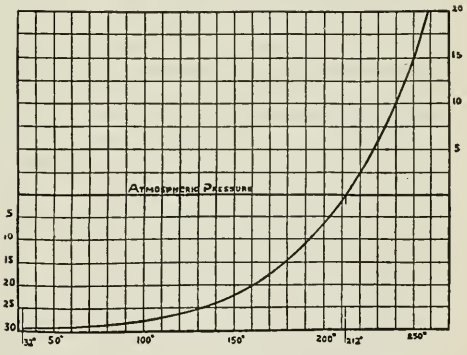


Fig. 4.

rapid pumping and boiling of suitable chemicals for the disintegration of scale.

There are certain acid salts which require special construction in order to line the evaporator with lead. This lead lining has never been done on a very large scale. In principle it consists in first pickling in sulphuric acid the plates of the machine, these being built with flanges that can be bolted together. The pickled surface is then given a tin coating. A sheet of lead of the proper thickness and size is coated with tin. The two tinned surfaces are laid together and the lead hammered to fit. Then the lead is "sweated" on by heating the iron from the outside to the melting

point of the tin plating, which is lower than that of the lead. In this way the lead lining becomes attached to the steel by a homogeneous weld. Where the flanges are bolted together the contact of the two lead surfaces generally prevents leakage, but can be made more sure by the process of lead-burning.

It is generally most expedient to work out the size of the heating bank from the amount of heating surface determined upon before deciding upon the general dimensions of the shell of the evaporator. The first thing to consider is the bore of tubing to be used. If we are dealing with a vertical type of evaporator where the tubes are expanded into two horizontal tube sheets, the bore of the tubing is determined by the nature of the liquid which is to be evaporated in them and the magnitude of the work to be accomplished. In the case of the horizontal type of evaporator where the steam is in the inside of the tubes and the liquor on the outside, there has been found a ratio of length to diameter for which the steam that condenses within gives a maximum evaporative capacity. If the tubes are too long and constricted, the steam will condense before it can pass to the far end of them, and a certain amount of heating surface is thereby wasted. It is usual to decide upon a certain length and diameter of tubing, however, arbitrarily from experience. It is then easy to decide, from the nature of the solution and taking into account the temperature differences and rate of evaporation, the proportioning of the heating bank. In a vertical effect when the length, diameter and center line distances are decided it is merely a question of filling a certain number of tubes in the minimum-sized circle.

Tubes may be attached to the tube heads or tube sheets by one of two methods, that of packing them in or expanding them in. To pack the tube in the tube sheet well, the hole in the sheet must be countersunk conically to admit of the forcing in of the rubber packing. This rubber ring is pressed in by a metallic place so that it is forced against the hole in the tube sheet by a stud bolt, and is arranged to hold down four, six or eight packing rings simultaneously.

When tubes are expanded into the tube sheet, it is expected that they are to be removed at no time during their life, whereas packed tubes can be easily removed, cleaned and repacked. Tubes expanded into the tube sheets properly make a perfectly steam-tight joint for almost any pressure of vacuum. The tubes are extended through the sheets a slight distance and are beaded over and are expanded by a special tool for this purpose. The Prosser expander rolls a corrugation in the tube, just inside of the sheet and beads it outside the sheet. In this way the sheet is braced against pressure from within or without. The Dudgeon expander rolls the tube flat against the side of the hole and beads it over on the outside. This method is not as effective in results, but is less of a strain on the metal of the tube.

I hope at a later date it may be possible to go more deeply into the practical side of this subject, presenting as far as possible the best solutions to problems arising from day to day.

INTERPRETATION OF GAS ANALYSES.

By W. D. BROWN.

Carnegie Steel Company, Duquesne Steel Works and Furnaces.

In endeavoring to find the meaning of a gas analysis and the relationship of a flue gas to the fuel used, the writer has prepared some formulæ which may be of benefit to others. In comparing gases the calculations are much simplified if the percentage of volume are used instead of the percentage of weight. The symbols of the different gases herein apply to the percentage by volume. As some formulæ contain the constituents of both the fuel gas and the flue gas, prime (′) is placed after the symbol of the constituents of the flue gas to distinguish them from those of the fuel gas.

Excess Air.

A flue gas generally contains oxygen and carbon monoxide besides carbon dioxide and nitrogen. Since one volume of oxygen combines with two volumes carbon monoxide, the oxygen required to combine with the carbon monoxide of the flue gas would be one-half the volume of carbon monoxide, and the excess is $(O_2' - \frac{1}{2}CO')$. The excess air is the excess oxygen divided by the percentage of oxygen in air (20.9). Excess air is, however, generally stated as percentage of amount required for perfect combustion. The excess nitrogen (XN) is 3.78 times the excess oxygen, or, avoiding fractions,

(1) $XN = 1.89\ (2O_2' - CO')$.

The nitrogen found in exit gases (N′) is the sum of the nitrogen of a perfect flue gas (tN) and the excess nitrogen (XN), therefore $tN = N' - XN$. Substituting for Nx its value we obtain equation

(2) $tN = N' - 1.89\ (2O_2' - CO')$.

By dividing equations (1) by (2) we have equation

$$(3)\quad \frac{XN}{tN} = \frac{1.89\ (2O_2' - CO')}{N' - 1.89\ (2O_2' - CO')}$$

In burning a fuel containing no nitrogen, the nitrogen of perfect flue gas (tN), coming only from the air, is the nitrogen of air necessary for complete combustion (aN). Therefore, substituting for (tN) in equation (3) its equal (aN) we derive equation

$$(4)\quad \frac{XN}{aN} = \frac{1.89\ (2O_2' - CO')}{N' - 1.89\ (2O_2' - CO')}$$

This is the ratio of excess nitrogen to necessary nitrogen, and is the same as the ratio of excess air to necessary air. Coal contains a small amount of nitrogen, but the error introduced by disregarding it is negligible, and the foregoing formula multiplied by 100, shows the percentage of excess air using coal as a fuel.

However, in burning a gaseous fuel containing nitrogen, another factor is introduced and the for-

mula is more complicated. From a study of the actions of burning gases it is seen that two volumes of carbon monoxide or hydrogen combine with one volume oxygen, one volume methane with two volumes oxygen, one volume ethylene with three volumes oxygen, and two volumes ethane with seven volumes oxygen. The gas may contain some oxygen and the amount required is diminished by that amount. The oxygen necessary for complete combustion is then $(\frac{1}{2}CO + \frac{1}{2}H_2 + 2CH_4 + 3C_2H_4 + 7/2C_2H_6 - O_2)$. The necessary nitrogen (aN) is 3.78 times the oxygen. Avoiding fractions, we have equation

(5) $aN = 1.89\ (CO + H_2 + 4CH_4 + 6C_2H_4 + 7C_2H_6 - 2O_2)$.

The nitrogen of perfect flue gas (tN) equals the sum of the nitrogen of the original gas (N) and the nitrogen of air necessary for complete combustion (aN), or $tN = N + aN$. Substituting for aN its value we obtain equation

(6) $tN = N + 1.89\ (CO + H_2 + 4CH_4 + 6C_2H_4 + 7C_2H_6 - 2O_2)$.

By dividing equations (6) by (5) and multiplying by (3), we obtain the ratio of nitrogen of excess air (XN) to the nitrogen of necessary air (aN):

$$\frac{XN}{aN} = \frac{N + 1.89\ (CO + H_2 + 4CH_4 + 6C_2H_4 + 7C_2H_6 - 2O_2)}{1.89\ (CO + H_2 + 4CH_4 + 6C_2H_4 + 7C_2H_6 - 2O_2)} \times \frac{1.89\ (2O_2' - CO')}{N - 1.89\ (2O_2' - CO')}$$

This is the ratio of excess air to necessary air and the percentage of excess air, using gas as a fuel, is found by multiplying the second member of the above equation by 100.

The Composition of a Perfect Flue Gas.

The carbon dioxide formed on combustion of a gas is one volume for each atom of carbon in the constituents of the gas. Thus one volume carbon monoxide and methane each produce one volume carbon dioxide, and one volume ethylene and ethane each produce two volumes carbon dioxide. The carbon dioxide of the fuel gas enters the flue gas; therefore, the carbon dioxide of the flue gas, showing perfect combustion or

$tCO_2 = CO_2 + CO + CH_4 + 2C_2H_4 + 2C_2H_6$.

$tN_2 = N_2 + 1.89\ (CO + H_2 + 4CH_4 + 6C_2H_4 + 7C_2H_6 - 2O_2)$.

The volume of the carbon dioxide and nitrogen being given their percentages can be found by dividing either by their sum and multiplying by 100.

In blast furnace gas, where ethylene and ethane equal zero, and consequently $(N_2 + CO_2 + CO + CH_4) = (100 - H_2)$,

$$\text{Per cent } tCO_2 = \frac{100\ (CO_2 + CO + CH_4)}{100 - H_2 + 1.89\ (CO + H_2 + 4CH_4)}$$

The percentage composition of a solid fuel is given by weight. In studying the reactions of combustion, it is seen that thirty-two pounds of oxygen, occupying a definite volume, expressed as 1-V, and accompanied by 3.78-V nitrogen, combine with either twelve pounds carbon to produce 1-V carbon dioxide, or with four pounds hydrogen to produce 2-V of water vapor. The oxygen of the fuel is considered to unite with its equivalent of hydrogen in the coal, eight pounds of oxygen with one pound hydrogen. The hydrogen available for combustion with air is therefore $(H - \frac{1}{8}O)$, the symbols applying to the percentage by weight of the elements in the coal. 1-V carbon dioxide being produced by twelve pounds carbon, the total volume of carbon dioxide in the gases is one-twelfth of the carbon or $CO_2 = 1/12C$-V. The volume of nitrogen from air is 3.78-V for twelve pounds carbon or four pounds available hydrogen, or $N_2 = 3.78\ [1/12c + \frac{1}{4}\ (H - \frac{1}{8}O)]$-V. The water is considered to be at saturation point at the temperature of analysis. There remains, therefore, the carbon dioxide and the nitrogen as given above. The percentage of carbon dioxide is found by dividing the carbon dioxide by the sum of carbon dioxide and nitrogen and multiplying by 100. Clearing this of fractions,

$$\text{Percentage } tCO_2 = \frac{100C}{C + 3.78\ (C + 3H - \frac{3}{8}O)}$$

The percentage of nitrogen of the coal being small, the error introduced by its omission is negligible, being 0.01% carbon dioxide. Sulphur in coal on combustion produces sulphur dioxide in the flue gas. On the same basis as given above ($CO_2 = C$-V), sulphur dioxide = three-eighths of the sulphur existing as pyrites, and the nitrogen is increased by one and nine-tenths times the sulphur. The error introduced by disregarding sulphur is less than 0.1% sulphur dioxide for 1% sulphur. The percentage of carbon dioxide is also in error by less than 0.1% for 1% of sulphur existing as pyrites.

N. W. Lord* gives analysis of seven grades of coal. The carbon dioxide of the perfect flue gas from these coals is as follows:

Anthracite culm, Scranton, Pa.	19.5%	CO_2
Semi-anthracite, Coalhill, Ark.	19.0%	"
Semi-bituminous, Mora, W. Va.	18.8%	"
Bituminous coking, Connellsville, Pa.	18.8%	"
Bituminous non-coking, Hocking Valley, O.	18.7%	"
Sub-bituminous, Unita Co., Wyo.	18.9%	"
Lignite, Milan Co., Texas	19.2%	"

A flue gas containing only carbon dioxide and nitrogen is impracticable. A flue gas generally contains carbon monoxide (CO′) and oxygen (C_2'). If this carbon monoxide were combined with the oxygen thus, $2CO' + O_2' = 2CO_2'$, the carbon dioxide would be $(CO_2' + CO')$, and the oxygen, being diminished by an amount equal to one-half the carbon monoxide, would be $(O_2' - \frac{1}{2}CO')$. The gas then would be a mixture of the perfect flue gas and of excess air. The perfect flue gas would then be the total carbon dioxide $(CO_2' + CO')$ divided by the theoretical carbon

* Chemical Engineer, 1908, Vol. VIII, p. 116.

dioxide of the perfect flue gas (tCO_2). The excess air is the remaining oxygen ($O_2' - \frac{1}{2}CO'$) divided by the percentage of oxygen in air (20.9). The sum of these two is unity. Therefore

$$\frac{CO_2' + CO}{tCO_2} + \frac{O_2' - \frac{1}{2}CO'}{20.9} = 1.$$

The theoretical carbon dioxide (tCO_2) is found for gaseous and solid fuel by the foregoing formulæ. Flue gas may, therefore, be checked against gaseous fuel or against coal.

Producer Gas.

Pure carbon on perfect combustion in air gives a flue gas of one volume of carbon dioxide and 3.78 volumes of nitrogen. If this carbon has only one-half enough air, it will burn to carbon monoxide, giving two volumes carbon monoxide to 3.78 volumes nitrogen. The two volumes carbon monoxide, however, burn with one volume oxygen, and 3.78 volumes nitrogen, forming, all told, two volumes carbon dioxide and twice 3.78 volumes nitrogen. The ratio is the same as if the carbon were burnt entirely at one stage. If the carbon gets its oxygen from water, carbon monoxide and hydrogen are formed in equal volumes. On burning the carbon monoxide and hydrogen with sufficient air, one volume carbon dioxide, one volume water vapor, and 3.78 volumes nitrogen are formed. An analysis shows no water present, since the gases are saturated, and the remaining flue gas has the composition one volume carbon dioxide to 3.78 volumes nitrogen.

It is evident, therefore, that no matter what the intermediate products of combustion are, or whether the oxygen is supplied by air or water, the final products of combustion, as shown by gas analysis, will be the same as if the carbon were burnt entirely to carbon dioxide at one stage. The theoretical carbon dioxide of the flue gas from producer gas as found from the producer gas by the formula,

$$\text{Per cent } tCO_2 = \frac{100\,(CO_2 + CO + CH_4 + 2C_2H_4)}{N_2 + (CO_2 + CO + CH_4 + 2C_2H_4) + 1.80\,(CO + H_2 + 4CH_4 + 6C_2H_4 - 2O_2)}$$

should check that found from the coal used, as derived by the formula (using the ultimate analysis of coal),

$$\text{Per cent } tCO_2 = \frac{100C}{C + 3.78\,(C + 3H - \frac{3}{8}O)}$$

Blast Furnace Gas.

The blast furnace has been styled a huge producer. In the blast furnace some of the oxygen comes from the ore to be reduced, the carbon getting the remaining oxygen from the air, or the moisture in the air. Carbon monoxide is formed when the air enters the furnace and strikes incandescent carbon, seventy-two pounds carbon unite with three volumes oxygen to produce six volumes carbon monoxide and three times 3.78 volumes nitrogen. The six volumes carbon monoxide reduce two hundred and twenty-four pounds iron with the formation of six volumes carbon dioxide, and the final products are six volumes carbon dioxide and three times 3.78 volumes nitrogen. If the two hundred and twenty-four pounds iron were reduced by solid carbon, thirty-six pounds would be required and three volumes carbon dioxide would be formed during reduction. There remains, then, thirty-six pounds carbon which combine with air (partly in the furnace and partly in the stoves), producing three volumes carbon dioxide and three times 3.78 volumes nitrogen. The total products from the seventy-two pounds of carbon, reducing two hundred and twenty-four pounds iron, are six volumes carbon dioxide and three times 3.78 volumes nitrogen, whether the reduction of the iron be by carbon monoxide or by solid carbon. For the sake of simplicity reduction is assumed to be by solid carbon.

From a study of the reactions it is seen that twelve pounds carbon reduce 74.5 pounds Fe from Fe_2O_3, 28 pounds Si, 55 pounds Mn, or 24.8 pounds P. Otherwise stated, the carbon required for reduction is 0.161 pound for 1 pound Fe, .428 pound for 1 pound Si, .218 pound for 1 pound Mn, and .484 pound for 1 pound P. Therefore, the amount of carbon required for the reduction of pig may be found from the analysis, by the following: Carbon to reduce 1 ton of pig, (R) = .00161 Fe + .00428 Si + .00218 Mn + .00484 P. For basic iron the value (R) is .160 ton carbon; for foundry iron, (R) = .165. About 3.5% of carbon enters the pig, therefore the carbon in a ton of pig (P) = .035 ton.

When carbon reduces the ore the product is carbon dioxide and no nitrogen. The carbon remaining from the reduction and impregnation burns with air, the products, carbon dioxide and nitrogen, having the same ratio (3.78) as oxygen and nitrogen in air. Also carbon dioxide from the decomposition of the limestone enters the gases. One ton of carbon in coke or limestone produces, we will say, one volume carbon dioxide, and when the carbon is burnt in air, 3.78 volumes nitrogen also. The carbon dioxide formed is therefore the sum of the carbon in limestone (S) and in coke (C) minus the carbon in pig (P) or $CO_2 = S + C - P$. The nitrogen is then 3.78 times the carbon burning in air, or $N_2 = 3.78\,(C - R - P)$. If R = 0.160 and P = 0.035, the theoretical per cent of CO_2 in the flue gas is

$$\frac{100\,(S + C - .035)}{S + C - .035 + 3.78\,(C - .195)}.$$

An error in the calculation of 100 pounds limestone, or 50 pounds carbon per ton of pig, or an error of 2% of the carbon in coke, causes an error of 0.1% carbon dioxide. Therefore the carbon dioxide of the true flue gas as calculated from the furnace should approximate the value calculated from the gas.

THE CARTER PROCESS OF WHITE LEAD MANUFACTURE.*

By J. S. STAUDT.

This company has two plants in the United States: one in Chicago, Ill., and the other in Omaha, Neb. The former has a capacity of about 20,000 tons annually and the latter of about 10,000 tons annually.

All descriptions and illustrations as herein given refer to the Omaha plant.

The lead bars or pigs, weighing about 95 lbs. each, are drawn up a chain elevator at the rate of 500 pigs per day, to be melted in a cast iron trough about 8 feet long, 18 inches wide and 12 inches deep, placed upon the second floor of what is called the "blow room." The lead is melted by means of a coal fire placed immediately below the trough.

On the side of the trough opposite the elevator is an opening through which pass two concentric tubes. The inner tube, nozzle shaped, serves for the passage of molten lead, and the outer for the passage of superheated steam. The tubes lead or open into a large iron compartment, about 33 feet long and 10 feet high, with

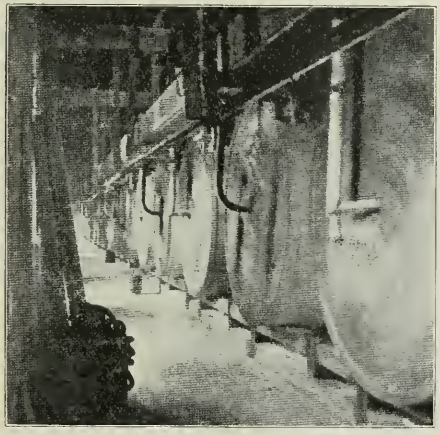


Fig. 1.—Corroding Cylinders.

a maximum depth of about 10 feet, tapering toward the base. Superheated steam is here produced by the same source of heat used in melting the lead, and is thus made as needed. It is the action of this superheated steam, blown against the molten lead, blowing it against the walls of the compartment, that reduces it into a finely divided state, granular and blue in appearance, called "blue lead."

The blown lead is not supposed to be oxidized before being put into the corroding cylinders. It will, however, undergo a slight oxidation when subjected to the moist air and the gases of the plant. When heaped up it will rise in temperature and become partly oxidized. Trap doors at the bottom of the iron compartment serve as means for the removal of the blown lead. The blown lead is removed by means of iron trucks, mounted on cast iron wheels, each truck holding about 4,000 lbs. Each truck is hauled upon an elevator and raised to the third floor. The contents are then dumped through an opening leading into a "corroding cylinder," on the second floor beneath. All the "corroding cylinders" are filled in this way, each

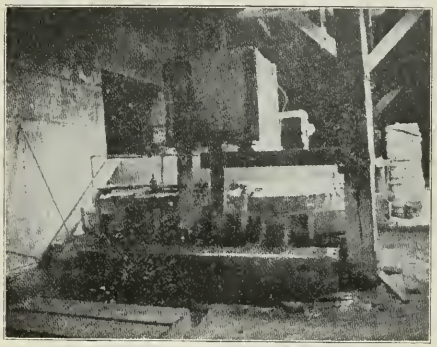


Fig. 2.—Classifiers.

"blue cylinder" receiving about 4,000 lbs. of blown lead. In the "corroding room" there are 69 "blue cylinders," as they are called, and 58 "white cylinders." The cylinders are made of wooden planks 2 inches thick, are 10 feet long and 8 feet in diameter. Lead is kept in the "blue cylinders" for 10 days, 16 lbs. of acetic acid being added for three days. For the remaining seven days it is sprinkled with cold water by means of a hose, inserted through an opening in the end of the cylinder. This is done twice a day, once in the morning and once in the evening. The carbon dioxide enters the cylinder through a 2-inch pipe inserted through an opening in the axis of one end of each cylinder. The cylinders revolve very slowly, making one revolution in nine minutes. The function of the cylinders is twofold: first, it serves as a grinder in so far as the particles rub against each other while the cylinder revolves; second, it serves to expose more lead to the corroding influences of acetic acid and carbon dioxide gas.

The corrosion is only partially completed in the "blue cylinders." The product is taken from these cylinders by means of vertical chutes, leading to trucks on the ground floor. Loaded trucks are taken by means of an elevator to the tower, dumped into a large hopper, leading into a mill grinding it into a fine powder. From this mill it leads into a large vertical chute 4 feet by 4 feet to the ground floor. Trucks are hauled under the orifice of this chute, filled with the ground product, and elevated to the third floor to be dumped into the "white cylinders." There are 58 "white cylinders" having the same dimensions and

*Journal of Industrial and Engineering Chemistry, November, 1909.

period of revolution as the blue. The product is removed from these through wooden vertical chutes, leading to the ground floor where it is dumped through an opening in the floor into a chute leading to a grinding mill below the floor.

The ground white lead is then washed with water, passed through the classifiers, four of which are in the corroding room south of the mill. The classifiers serve the purpose of separating the coarse particles

Fig. 3.—Pepper Mill and Settling Plant.

from the fine. Abundant water is used here so as to cause it to flow and at the same time wash it. The finest separation from the classifiers goes over the "shakers" where it is still further separated. The "shakers" consist of a framework covered with silk of very fine mesh. This framework is moved back and forth in a horizontal direction by means of a piston. The liquid white lead is fed upon the sieve by means of openings in the bottom of a trough at the head of the sieve. An operator regulates the flow by taking out or inserting wooden pegs fitting these openings. The part that goes through the fine silken sieve passes by the action of gravity through pipes slightly inclined to the "settling tanks" on the ground floor. The coarse from the four classifiers above referred to as well as from the "shakers" passes through conduits leading into a main which in turn leads through an opening in the axis of the north end of a pebble mill, also on the ground floor. Only one pebble mill is used. It is about 10 feet long and 4 feet in diameter, partially filled with pebble stones from 3 inches to 4 inches in diameter. From the axis of the south end of the mill the ground material escapes, passes through an inclined conduit into an adjacent bin from which it is pumped through a 2-inch pipe up to the two "classifiers" on the third floor. Here it is again separated into coarse and fine, the fine flowing through wooden conduits to the "shakers." The coarse from this having gone over the classifiers and through the pebble mill now passes through a revolving screen (silken), located on the ground floor. This separates the tailings—consisting of particles of wood, coarse white lead and uncorroded lead—from the good product which drops into a large bin below the revolving screen.

The tailings are sold for what the lead is worth for the making of litharge and red lead.

The "settling tanks" are 13 in number, arranged in two rows running north and south on the ground floor. The tanks are about 11 feet in diameter, and about 5 feet high, tapering toward the top. These tanks are filled with the fine product from the 'shakers" diluted with plenty of water. The product as it comes from the "white cylinder" is partly basic lead carbonate and partly lead acetate. Acetic acid acting on the lead forms basic lead acetate in the presence of air. The carbon dioxide acting on the basic lead acetate forms lead carbonate and lead acetate. This is the product that goes into the settling tanks together with a large quantity of water. Two bucketfuls of soda solution are added to each tank. This solution is made by dissolving 150 lbs. of Na_2CO_3 in one barrel of water. The sodium carbonate acting on the lead acetate changes it into lead carbonate. The contents of the "settling tanks" are agitated by means of an agitator, consisting of a wooden plank extending down into the basin with a cross piece at the end. Each tank is provided with an agitator. They are attached to horizontal shafts above each row, extending the full length of the rows and rotated back and forth by means of a piston rod. The white lead is kept in these "settling

Fig. 4.—Drying Pans.

tanks" for about fifteen hours, agitated part of the time and then settled. The solution is tested for acetate or free acetic acid by a 10 per cent solution of potassium iodide. After the contents of the basins are thoroughly settled the water is removed from holes, fitted with wooden pegs extending down one side of the tank. By the removal of these pegs the water can be removed to any desired depth. Great care is taken that the excess of soda is washed out of the precipitate since it saponifies with the oil which is later added. Phenolphthalein solution is used to test for the carbonate. The water thus removed is passed through an 8-foot sewer pipe to a "settling basin" about 75 feet east of the building. It consists of a hole dug out

with concrete. Here a further precipitation of white lead, held in suspension by the water, takes place. The settlings from this basin are removed about once every three months.

Pure white lead now constitutes the settlings from the "settling tanks" which are removed through openings in the sides of the basins near the bottom, emptying into deep and wide wooden flumes, immediately below the floor. These flumes are inclined so that the white lead slowly flows into a bin below the floor at the north end of the room.

From this bin it is pumped through a 3-inch lead pipe into the "dry room" on the third floor at the north end of the building.

The "dry room" consists of two bins 100 feet long, one on the east side and one on the west side. These bins are provided with iron pans lined with copper, extending through the full length of the bins. The

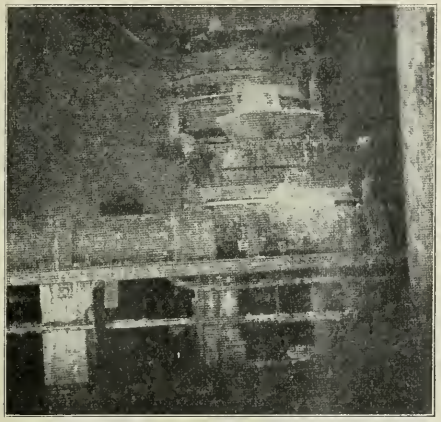


Fig. 5.—Mixer.

east bin contains five pans and the west bin four. Each pan has a double bottom. Steam circulates through the hollow thus provided, furnishing heat by which the white lead is dried. It requires about five days for the white lead in each pan to dry, in which state it cracks and breaks up into blocks very similar to mud drying in the sun. When dry it is removed by means of a shovel, passed through chutes to the room below called the "mixing room." Two mixing machines are in this room, one at the north end and another at the south end. In these machines about 32 lbs. of linseed oil are mixed with 500 lbs. of white lead. Two kinds of linseed oil are used—boiled and unboiled. Boiled oil serves as a bleaching agent. The ratio of boiled to unboiled oil is approximately 1 to 1. "Pulp lead," i. e., white lead which has never been dried, is also mixed with oil at the rate of 11 lbs. oil to 100 lbs. white lead. Some is mixed with oil by taking it one-half pulp and one-half dried. It is preferred this way by a great many painters. Again, a great deal is shipped without being mixed with oil at all, either as pulp, dried, or a mixture of the two.

From each mixing machine the white lead is conveyed by means of screw conveyors placed horizontally near the floor. At various intervals there are pipes passing through the floor to hoppers leading into machines on the ground floor in which the mixing is completed. A great deal of heat is generated in these machines due to the saponifying action of the oil on the $Pb(OH)_2$. The machines are kept cool by cold water circulating through conduits encircling the machines.

With these machines the Carter Process of White Lead Manufacture ends. From the exits of these machines it is packed into kegs varying in capacity from 12½ to 500 lbs. The daily output of the Omaha plant is about 32,000 lbs.

The U. S. Civil Service Commission, Washington, D. C., will hold an examination on March 3, 1910, to secure eligibles from which to make certification to fill a vacancy in the position of technical assistant in pharmacology (male), Division of Pharmacology, Hygienic Laboratory, Public Health and Marine Hospital Service, at $1,800 per annum, and vacancies requiring similar qualifications as they may occur, unless it shall be decided in the interests of the service to fill the vacancy by reinstatement, transfer, or promotion. It will not be necessary for applicants to appear at any place for examination. The examination will consist of the subjects mentioned below, weighted as indicated:

Subjects.	Weights.
1. College education or its equivalent.....	20
2. Postgraduate work relating especially to Pharmacology or chemistry.....	30
3. Special experience in pharmacology or allied subjects	25
4. Publications of original investigations in pharmacology or allied subjects.....	25
Total	100

Applicants must indicate in their applications that they are thoroughly trained in general chemistry and that in addition they have paid especial attention to the chemistry of the United States and other pharmacopœias, and to organic chemistry in its relation to physiology and pharmacology; that they are qualified to undertake original investigations on the physical constants of the pharmacopœia and related subjects as well as in synthetic chemistry as related to medicine. They should have received the degree of Doctor of Philosophy from institutions of high standing, and their studies should have been along the lines indicated above. These facts must be fully stated in the application. Applicants must submit unequivocal evidence of ability to do research work. They must also indicate in their applications that they have a reading knowledge of French and German.

THE GAYLEY DRY BLAST APPLIANCE IMPROVED.

An altered design for dry blast apparatus has been specified by James Gayley in a recently issued patent. The improvement consists in a protection against the fluctuations of outside temperatures for the air conduit leading to the blowing engines, thereby supplying a uniform weight of air to the furnace. To quote, in further explanation, from Mr. Gayley: "The raw materials of the furnace are made as uniform as possible, but the air consumed per ton of iron is 50 per cent greater by weight than the raw material; and it is therefore important to deliver air to the furnace which is uniform in weight, as well as in moisture content per unit of volume. The variation in the weight of air will increase or retard the rapidity of combustion of the fuel in the blast furnace, and thus cause a change in the fusion or combustion zone of the furnace. Such a change in this zone often causes the furnace charge to stick or hang on the walls, and these hanging portions, when dislodged, cool off the furnace hearth and interfere with the uniformity of furnace operation and the grade of metal produced. These disturbances, I have found to exist independently of the percentage of moisture in the air, since air of varying temperatures can, and often does, contain the same quantity of moisture. Air of varying temperatures, however, cannot contain the same weight per unit of volume; and the purpose of my present invention is to secure better uniformity in the metallurgical process by supplying air of substantially uniform temperature and therefore uniform weight, as well as of substantially uniform moisture content to the blowing engine, and hence to the furnace or metallurgical apparatus. In carrying out this discovery when air-drying apparatus is remote from the blowing engine, I jacket or otherwise protect the air conduit leading from the air-drying apparatus to the blowing engine, in order to preserve a substantially uniform temperature of air therein, and thus supply air of substantially uniform weight, as well as substantially uniform moisture content, to the blowing engine."

IMPROVEMENT IN BLOWING ENGINE CONSTRUCTION.

The novel design of blowing engine tub, invented by E. E. Slick, of the Carnegie Steel Company, is described in The Iron Age (Dec. 9, page 1773). As described by the writer, S. Rice, the essential features are as follows: The inlet ports are located in the barrel of the tub and consist of a series of circular openings extending entirely around the circumference of the barrel at each end. The barrel is not attached to the heads, but is supported on independent slides and by suitable connections is made to reciprocate while the heads are held stationary. This construction gives great inlet area for very small motion of the barrel and leaves the entire area of the heads free for discharge valves, making it possible to secure great discharge area.

SIMPLE SPECIFICATIONS FOR COAL.

Mr. Edward C. Sherman, in a letter to the Engineering News of October 28th, gives the following set of specifications which were used for the purchase of anthracite coal by the Charles River Basin Commission of Massachusetts. These specifications are much simpler than those ordinarily employed, and consequently are suitable to use where only a small quantity of coal is purchased.

These specifications follow:

The bidder must state with his quotation what percentage of ash the coal which he proposes to furnish will contain and payment will be made on the basis of the price named in the proposal, corrected for variations of ash and also corrected for sulphur in excess of 1%, both as shown by chemical analysis. These corrections will be made as follows:

For an increase up to 2% in the ash contained above or below the standard established by the contractor no correction will be made in the price. When the variation exceeds 2% above or below the standard, corrections in the price will be made as follows: For variations from the standard percentage of ash exceeding 2 and less than 2.5 above and below, the deduction or addition of 15 cts. per ton, respectively, will be made; for each additional ½ or 1% or fraction thereof, in excess of 2.5%, 3 cts. per ton more will be deducted or added, respectively. This deduction will be made up to a maximum ash of 14%. For each additional ½ of 1% or fraction thereof in excess of 14%, 6 cts. per ton more will be deducted.

When the sulphur exceeds 1% further correction in the price will be made as follows: For each one hundredth of 1% in excess of 1% the sum of ½ ct. per ton will be deducted.

The commission reserves the right to reject any coal which contains ash in excess of 15% or sulphur in excess of 1.75%. In case of such rejection the contractor shall, at his own expense, remove the coal within ten days after being notified so to do.

Proposals shall be made on the basis of tons of 2,000 lbs. Sworn statements of the weights delivered shall be sent to the commission within two days after each delivery.

Samples of the coal will be taken at the time of delivery, and the contractor may, if he desires, have a representative present to see the samples taken and sealed. The sampling will be done as follows: Not less than 100 lbs. will be taken in small lots from various parts of the delivery; this will be mixed and a sample weighing about 5 lbs. will be taken from it, which will be analyzed. A copy of the result of the analysis will be mailed to the contractor as soon as it is received. Coal containing an excessive amount of dust and fine coal will not be accepted.

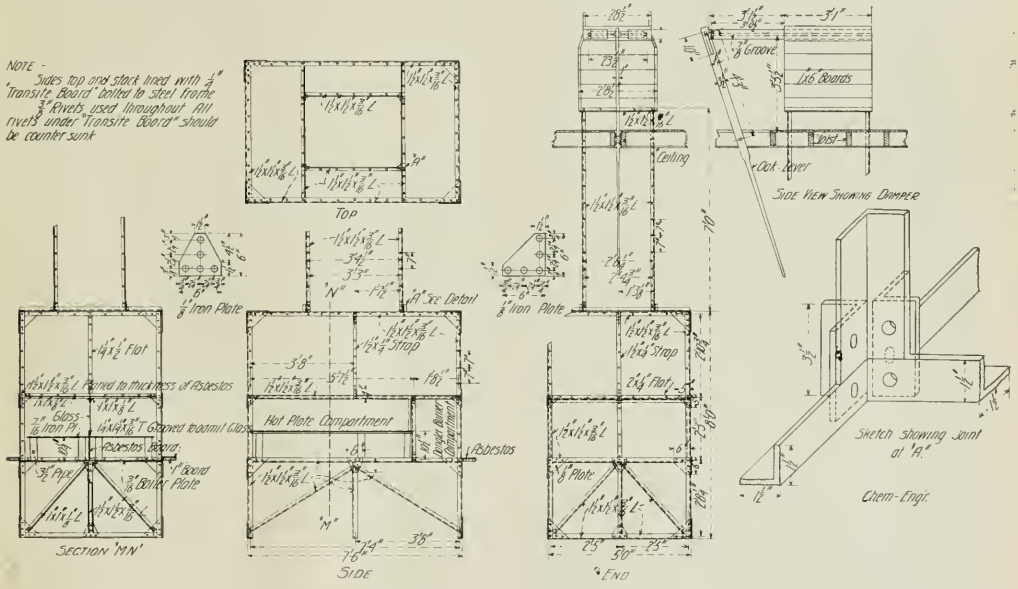
THE LABORATORY

A HOOD, SUITABLE FOR LABORATORIES WHERE GASOLINE IS USED TO HEAT THE HOT PLATES AND SUPPLY THE FUEL FOR THE BLAST LAMPS.

DESIGNED BY H. S. SHERMAN, EVELETH, MINN.
Chemist for Oliver Iron Mining Co., Fayal Laboratory.

The frame is made of light angle iron riveted in sections, the sections are riveted together making the frame work complete. The frame is given two coats of asphaltum before the asbestos board is bolted on. plates, having small pieces of asbestos board in the center to separate the lower compartments. The asbestos is placed between the hot plates and projecting about three inches above the working surface of the plate at the back, fitting against a grooved tee iron which holds the glass; this enables one to blacken the plate, and in case of accident, the glass is not broken from liquids being spilled on the plate.

We have five hoods in use at present of this general design, some smaller and one larger than the sketch. The one illustrated has been in service three and one-half years. Aside from a coat of asphaltum on the



Details of Steel Hood, Laboratory of the Oliver Iron Mining Co.

When completed, the only iron work exposed inside of the hood is the heads of the small bolts, and the steel frame holding the glass partition, all steel parts given two coverings of asphaltum paint.

The ¼ inch asbestos is fitted to each section and all seams are united under the different pieces of angles or straps of steel. The bottom plate is bolted to the frame and set in stove cement to make a tight joint and prevent the gasoline from leaking on the floor when generating the burners. The hood, being double, has a frame which holds pieces of window glass above the plates to prevent a draft across the top of the hot plates and the lower compartment beneath the hot iron work, we have had no repairs to make. The atmosphere does not show a condensation of moisture on the asbestos, thereby causing a sweat, when the length of the stack is confined to the inside of the building. We are using a stack 10 ft. long above the hood to shutter as this is sufficient for fire protection. The Dangler burners in the end create a forced draft when in use and save extra table room, making the burners more compact. All edges of asbestos not abutting another piece of asbestos are protected by small flanges of steel as will be noted in the sketch showing side openings.

The rivets under the asbestos must be counter-sunk

in order to enable a tight joint to be made and prevent the asbestos from warping. The hood is fireproof except the wooden shelves on the sides and the end. The stack can be made any size desired by changing the top angles. The shutter should fit over the stack just above the iron frame—not as the sketch shows, as this was the first stack erected. We have dropped the shutter to rest on the top of the stack. The design could be changed and material used for side wall hoods, but not to the same advantage as a double center hood.

We have found the hood easy to keep clean inside. The usual wooden hood which occupies a prominent place in most laboratories will be discarded for something along this line before many years, due to the restrictions of the fire insurance companies.

Aluminum is used in iron and steel works for removing oxygen from oxides of iron and other substances, the heat generated being so great as to raise the temperature of large bodies of iron. It also has the power of combining chemically with those gases imprisoned during the cooling of the metal, thus preventing porosity. For these purposes the metal is either used in the form of an alloy known as "ferro-aluminum," or as the pure metal, either in the granulated bar form or in small pieces weighing uniformly one-eighth ounce or one-fourth ounce each.

According to figures just given out by the Bureau of Statistics of the Department of Commerce and Labor, $2,332,000,000 worth of petroleum has been exported from the United States since that product began to be an article of exportation, less than 50 years ago. During the year ended June 30 last, mineral oils gained over 100,000,000 gallons in sales to foreign countries, and a gain of nearly $2,000,000 in value. In the last 50 years the total production of petroleum in the United States has aggregated fully 90,000,000,000 gallons.

Beehive coke ovens, such as will successfully coke Illinois or Indiana coal, can be constructed for from $400 to $450 each, complete, while the construction of by-product type of oven, not including by-product attachments, will approximate $1,200, while at least $2,000 will be required per oven for by-product plant, making a total cost for by-product oven, complete, not less than $3,200, on a battery of 100 ovens. These ovens would be capable of producing twice the amount of coke in a given time as compared with the beehive type.

Ferrotitanium contains 10 to 15 per cent of titanium, 5 to 7 per cent of carbon, and of other impurities less than 5 per cent; the balance is pure iron which has been electrically refined. In bessemer-steel manufacture it is the practice to add about 1 per cent crushed ferrotitanium in the ladle as the steel is poured from the converter.

INVENTIONS FOR RENDERING WOOD AND TEXTILES FIREPROOF.*

By WILLIAM H. HUNT.

For years engineers and inventors occupied themselves with efforts to discover means by which textiles and wood could be rendered uninflammable, or at least incapable of transmitting flame. The methods proposed to this end are very numerous, but few, if any, afford absolute guaranty. A perfect method has yet to be found.

The oldest researches in this line date as far back as 1821, when Louis XVIII charged Guy-Lussac, a celebrated chemist, to make a practical study of the means of preventing fires and rendering scenic effects of theaters incombustible. The methods proposed since then are for the most part but modifications of those advocated by Guy-Lussac; however, it cannot be denied that a certain progress has been made in this direction. The study of these methods is interesting and certain of them deserve more than passing notice, as they have given some practical results, permitting one to augur a satisfactory solution of this important question.

INCOMBUSTIBLE SUBSTANCES.

By the word "ignifuge" is understood substances capable of communicating to cellulose material the property of becoming uninflammable or incombustible, or at least depriving them of the faculty of transmitting flame. These substances are generally non-volatile mineral salts, neither fusible, deliquescent, nor hygrometric. The salts are dissolved in portions mentioned further on and frequently mixed with other substances to increase their power of adherence. The objects to be rendered fireproof are either steeped in these solutions or the liquid is applied with a brush. The salts most commonly employed are phosphates, tungstates, borates, and particularly ammonical salts, boric acid, chlorides of calcium, magnesium, zinc, silicate of soda.

Herr Lochtin, a German chemist, studied the effect of the different salts on the combustibility of tissues, and he found that preference should be given to sulphate of ammonia, phosphate of ammonia, chlorides of ammonia, and zinc, alum, borax, boric acid and alumin—the latter a precipitate of aluminate of soda. According to the author, the first three named, together with aluminate of soda, were the ones that gave the best results; the ammoniacal salts, volatilizing under the influence of heat, form, with the combustible gases, mixtures completely incombustible. The same might be said of chloride of calcium magnesium and zinc, while the action of alumin is purely mechanical.

The following substances would, according to Lochtin, possess but few qualities of incombustibility: Borate of alumin and zinc, phosphates of lime and magnesia, zinc, soda, tungstate of ammonia, sulphate of magnesia, acetates of soda and potash; while the sulphates,

*A paper published in the California Journal of Technology based upon a report by the French Chemists, Robine and Langlen.

sulphite, hyposulphites, silicates, carbonates of zinc, lime, magnesia and ferrous sulphates increase combustibility.

Without pretending to discuss the value of the experiments of the German chemist, it is only correct to say that several of these substances, and particularly silicate of soda, have been employed with success.

The simplest method, especially for textiles, recommended in 1889 by the Paris Board of Fire Commissioners, consists in steeping the materials in a 10 per cent solution of phosphate of ammonia, after which they are wrung out and placed to dry in the open air. The cloth is rendered a trifle stiff, but when exposed to the action of a flame it blackens without taking fire. This method is particularly appropriate for the flimsy material worn in certain religious ceremonies, at balls, theaters, etc.

THE ABEL MARTIN METHOD.

The Abel Martin method dates from 1879; presented before the Academy of Sciences, it received the felicitations of that learned assembly. The process is based on the employment of salts of ammonia, to which is added a certain proportion of borax and boric acid. Successful experiments were made in 1881 before a large assembly of people, and the process was adopted for rendering fireproof the scenic decorations of several theaters of Paris. The formulas of the Martin process follow:

For textiles: Sulphate of ammonia, 8; carbonate, 2.5; boric acid, 3; borax, 2; starch, 2; dextrin, 0.4; water, 100. The textile to be treated is steeped in this solution warmed to 86° F. After rinsing, it is put to dry in the air. A quart of the liquid is sufficient for 12 square yards.

For wood: Hydrochlorate of ammonia, 15; boric acid,5; gelatine, 50; chalk, 1.5; water, 100. The coating is applied with a brush, at a temperature of 140° F.

For wood, straw, calico and wrapping paper: Chloride of ammonia, 15; boric acid, 3; water, 100. The articles are steeped for 15 or 20 minutes in this solution, heated to 140° F.

For paper: Sulphate of ammonia, 8; boric acid, 3; borax, 2; water, 100. Impregnation is made at a temperature of 120° F.

OTHER FORMULAS.

The formulas of Venat and Herrard differ but slightly from the foregoing, and the same might be said of those of Schneider. Bastroirtz recommends the following mixture, which is claimed to have the additional virtue of rendering the textiles impermeable: Amphibolin, 34; glue, 2; chrome alum, 2; sulphate of ammonia, 2; water, 100.

Beaulieu Narconnay impregnates wood with a solution of polyboric salts in an excess of ammonia. Silicate of soda is very generally used on account of its cheapness for outhouses, partitions, boxes, barrels, etc. One of several coatings of a 10 per cent solution is rapidly applied with a brush; it is also used with other substances. Benevot incorporates silicate of soda (45 parts) with a solution of rosin (45 parts) in 100 parts of sulphide of carbon. Alumin salts have been recommended for incombustion. Ferrel obtained a coating by adding a carbonate to a solution of sulphate of aluminum.

Some authors employ coatings of a base composed of tungstates or stannates. Persin and Whipp steep the textiles for an hour in a solution of stannate of soda at 14° Baume. After drying they are put into a bath composed of the following parts at degrees Baume: Tungstate at 35°, 4; citric acid at 9°, 1; hydrochlorate of ammonia at 4°, 3; acetate of zinc at 17°, 17. After being dried a second time the tissue is passed through cylinders heated by steam to expel the organic acid.

Mention might be made of the coating of amiante employed in the London theaters. This substance, which possesses remarkable incombustible qualities, is mixed with paint or with silicate of soda or glycerin. The wood painted with this composition burns slowly, like niter paper, and never gives out a flame.

HOW WOOD SHOULD BE TREATED.

All these methods, however, give but partial satisfaction, as the materials, although incombustible in themselves, do not possess indefinite durability. Through atmospheric influences and wear and tear the coating falls into dust and must be frequently renewed. Moreover, certain of these substances possess the grave defect of affecting the color. However, for textiles nothing better has been found. Not so for wood, say Messrs. Robine and Lenglen. To operate properly, wood should be treated while green—that is, immediately after it is cut down—so as to impregnate by the process of osmosis the cells of the fiber. Several inventors propose as many methods, but all with a view of saturating the wood with the mineral solutions.

Payne (1841) brought forward a process consisting of placing the wood in recipients in which a vacuum was created and then introducing a solution of sulphate of iron; when this had well penetrated the pores of the wood, a solution of chloride of lime was added. By double decomposition sulphide of lime was formed, which filled up the cells. This process, with the addition of a salt of zinc, is still more or less used in the United States.

Thilmanz employed an analogous process, using solutions of sulphate of copper or zinc and barium chloride. Hely impregnated the wood with a concentrated solution of bisulphate of lime, and, finally, with a solution of lime, so as to form a monosulphide, which, oxidizing under the influence of the air, produced sulphate of lime that filled up the pores of the wood.

Hasselmann (1896) diminished notably the combustibility of wood by heating it first in a bath of sulphate of iron and sulphate of alumin, then in chloride calcium, to which he added a milk of lime. The opera-

tion lasted six hours at a temperature of 280° F. The cost of this method, it appears, was very low.

The Nodon-Bretonnean process involves the use of electricity. The wood is placed in large reservoirs containing the following solution, in percentages: Borax, 10; rosin, 5; carbonate of soda, 0.75. The wood is placed on a plate of lead communicating with the positive pole of a dynamo; the negative pole is connected with a similar plate at the upper end. Under the influence of the current the sap mounts, while the preserving solution takes its place. The operation lasts eight hours; the wood is afterwards dried.

PRESENT TENDENCY.

Within the last few years there has been a tendency to return to the ammoniacal salts, which, as has been seen, appear to have given the best results as regards incombustibility. The salts most employed are the sulphate, and especially the phosphate of ammonia in solution, which are injected under pressure into the wood.

It may be mentioned that in England a company has been formed for the manufacture of incombustible wood to be used on war vessels. It is understood that a similar company exists in the United States.

As to the stability of the agent of incombustion, opinions are divided. Some maintain that, the salts employed being stable themselves, the qualities of incombustibility persist, while others affirm that the wood gradually loses this property and in the end combustibility is more or less increased. In any case, the treatment mentioned protects the wood from insects and decay.

Rolled Manganese Steel Rails.

The Pennsylvania Steel Company has for some years been placing on the market various articles of manganese steel, all products being known as Manard Steel. Among these were rails, cast from the alloy steel, which have shown superior wearing quality. Tests of actual service have shown the wear to be 50 times greater than that of standard Bessemer rails.

One of the chief difficulties in the way of extending the use of Manard rails has been in the high cost of production. Aside from the high cost of patterns for preparing the molds for casting the rails, there was the expensive work of finishing the rails, grinding being the only available method. Other disadvantages in the cast rails are that they are not very uniform in composition and structure, and being but 20 feet in length, the number of joints is materially increased. The Company has, however, recently developed a process for rolling the rails, and the result is a product of remarkable toughness and ductility, as shown by the tortion tests.

The Manard rail will be used on curves, it having been shown to be 50 times more durable than the ordinary Bessemer rail. With the price of Bessemer rails at $28 the Manard rails are evidently cheaper even at their cost of $125.—*Iron Age*, lxxxiii, 16, 1261.

CHEMICAL CALCULATIONS.

To find the molecular weight from the formula.—Add the products obtained by multiplying the atomic weight of each element by the number of atoms of that element which make up the molecule as shown by the formula. The sum will be the molecular weight.

Example.—Find the molecular weight of ferric sulphate, $Fe_2(SO_4)_3$:

$$Fe_2 = 56 \times 2 = 112$$
$$S = 32 \times 1 = 32$$
$$O_4 = 16 \times 4 = 64$$
$$(SO_4)_3 = 96 \times 3 = 288$$

Molecular weight of $Fe_2(SO_4)_3 = 400$

To find the percentage composition from the formula.—Multiply the atomic weight of the element by the numer of atoms of this element there are in the molecule, multiply the product by 100, and divide by the molecular weight. The quotient is the percentage of that element in the compound.

Example.—Find the percentage composition of ferric oxide, Fe_2O_3:

Molecular weight of $Fe_2O_3 = 56 \times 2 + 16 \times 3 = 160$.

$$\text{Percent. of iron} = \frac{56 \times 2 \times 100}{160} = \frac{11200}{160} = 70.00$$

$$\text{Percent. of oxygen} = \frac{16 \times 3 \times 100}{160} = \frac{4800}{160} = 30.00$$

100.00

To find the weight of any given element in any given weight of a compound.—Multiply the atomic weight of the given element by the number of atoms of this element there are in a molecule of the compound; multiply the result by the given weight and divide by the molecular weight of the compound.

Example.—How much sulphur is there in 5 grams of barium thiosulphate, BaS_2O_3?

Molecular weight of $BaS_2O_3 = 249.4$.

$$\text{Weight of sulphur} = \frac{32 \times 2 \times 5}{249.4} = \frac{320}{249.4} = 1.283 \text{ gms.}$$

To find the empirical formula of a body from its percentage of composition or analysis.—Divide the percentage of each element by the atomic weight of that element. Carry the division to three decimal places. Divide all the numbers thus obtained by the lowest. If the numbers are not whole numbers reduce them to the simplest relation in whole numbers, and to each number so obtained prefix the symbol of the element to which it refers.

Example.—Find the empirical formula of a body whose percentage composition is

Calcium	38.72
Phosphorus	20.00
Oxygen	41.28
	100.00

$$Ca = \frac{38.72}{40} = 0.968 \qquad \frac{0.968}{0.645} = 1.50$$

$$P = \frac{20.00}{31} = 0.645 \qquad \frac{0.645}{0.645} = 1.00$$

$$O = \frac{41.28}{16} = 2.580 \qquad \frac{2.580}{0.645} = 4.00$$

The simplest ratio in whole numbers is 3:2:8 and the empirical formula is, therefore, $Ca_3P_2O_8$.

To find the weight of material required to produce or liberate a given weight of a substance.—First write the chemical equation (or equations) for the reaction. Next consider from this the number of molecules of the material required to produce one molecule of the substance. Now multiply the number obtained, by the molecular weight of the material and by the given weight of the substance produced or liberated. Divide the product by the molecular weight of the substance produced or liberated.

Example.—How much sulphuric acid is required to produce 5.0 grams of hydrogen?

Reaction: $H_2SO_4 + Zn = H_2 + ZnSO_4$.

1 molecule H_2SO_4 produces 1 molecule of H_2.

Molecular weight of $H_2SO_4 = 98$. Molecular weight of $H_2 = 2$.

Hence $\frac{98 \times 1 \times 5}{2}$ or 245 grams of sulphuric acid are required.

Example.—Find the weight of mercury necessary to produce 100 pounds of calomel, Hg_2Cl_2, by the two successive reactions.

$Hg_2 + 4H_2SO_4 = 2HgSO_4 + 4H_2O + 2SO_2$.

$Hg_2 + 2HgSO_4 + 4NaCl = 2Hg_2Cl_2 + 2Na_2SO_4$.

1 molecule of Hg_2 produces 2 molecules $HgSO_4$.

2 molecules of $HgSO_4$ and 1 additional molecule of Hg_2 produces 2 molecules of Hg_2Cl_2.

2 molecules Hg_2 produce 2 molecules Hg_2Cl_2, or 1 molecule Hg_2 produces 1 molecule Hg_2Cl_2.

Molecular weight of $Hg_2 = 200 \times 2 = 400$

Molecular weight of $Hg_2Cl_2 = 200 \times 2 + 35.5 \times 2 = 471$.

Hence $\frac{1 \times 400 \times 100}{471} = 84.9$ lbs. of mercury are necessary.

To find the weight of material required to produce a given volume of a gas.—First reduce the volume of gas to 0° C. and 760 mm. pressure. Next write the chemical equation (or equations) of the reaction. Now consider from this the number of molecules of the substance required to produce one molecule of the gas. Multiply the molecular weight of the material by this number, divide the product by 22.4 and multiply the quotient by the corrected volume (in liters) of gas required. The result will be the weight (in grams) of the material required to produce the given volume of gas. (The molecular weight in grams of any gas will occupy 22.4 liters at 0° C. and 760 mm. pressure.) If the volume of gas is given in cubic feet and the answer is desired in pounds, substitute 359 for 22.4.

Example.—Find weight of zinc necessary to produce 100 liters of hydrogen.

$Zn_2 + 2H_2SO_4 = 2ZnSO_4 + 2H_2$

1 molecule Zn_2 produces 2 molecules of H_2 or 1 atom Zn produces 1 molecule of H_2. Hence 65.4 grams Zn produces 224 liters H_2. For 100 liters of H_2, $\frac{65.4}{22.4} \times 100 = 292$ grams of Zn_2 will be required.

Example.—How much potassium chlorate is needed to produce 1000 cubic feet of oxygen

$2KClO_3 = 2KCl + 3O_2$

2 molecules of $KClO_3$ produce 3 molecules of O_2

⅔ molecule of $KClO_3$ produces 1 molecule of O_2

Molecular weight $KClO_3 = 39.2 + 35.5 + 16 \times 3 = 122.7$.

Hence $\frac{122.7 \times 2}{3} = 81.8$ lbs. of $KClO_3$ will produce 359 cu. ft. of O_2.

Therefore for 1,000 cu. ft. of O_2, $\frac{81.8}{359} \times 1{,}000 =$ 226.2 lbs. of $KClO_3$ will be required.

The principal source of selenium is in the anode muds or slimes of the electrolytic copper refineries. The American Smelters Securities plant at Baltimore, Md., the Perth Amboy and the Chrome, N. J., refineries all have made more or less selenium. The Baltimore and the Chrome refineries get their crude copper from many sources, but that handled at Perth Amboy comes almost exclusively from Butte, Mont. Great tonnages of copper are handled at each of the smelters and the selenium recovered represents only minute traces in the original ores. The anode slimes in the copper refineries contain a large percentage, in many cases 50 per cent or more, of gold and silver. The slimes are treated in very large cupellation furnaces, as large as the reverberatory furnaces which a comparatively few years ago were used for copper smelting. Selenium is collected in the flue dusts from this cupellation, and is recovered by processes which differ with the refinery and which are hardly to be considered as more than experimental.

The surface of the famous pitch lake of Trinidad is about 138 ft. above the sea; its area is 100 acres, and borings have shown that it fills a bowl-like depression with steep sides and a depth of more than 135 ft. This lake has been estimated to have a minimum available content of over 9,000,000 tons. More than 2,000,000 tons have been removed and exported since records have been kept. The exports in the year ending January 31, 1909, were 150,557 tons, of which 98,098 tons came to the United States.

METALLURGY.

DETERMINATION OF CARBON DIOXIDE IN ROCK AND PORTLAND CEMENT.

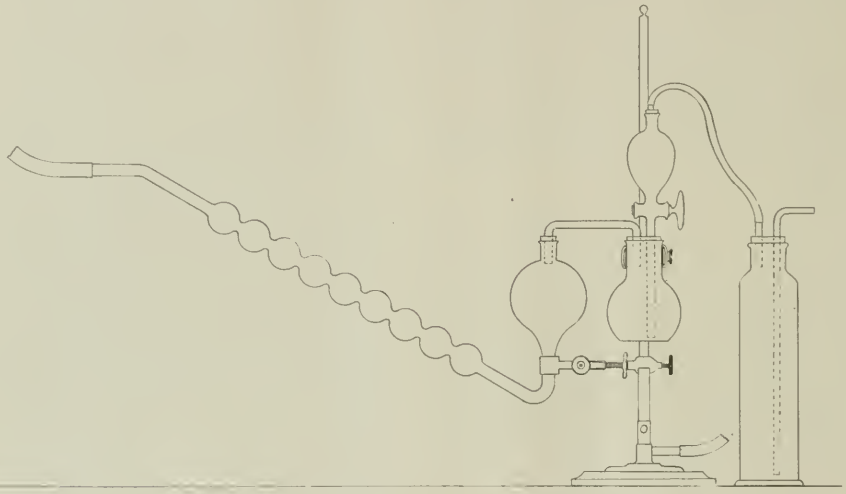
By HENRY WYSOR.

There are two practical methods now in use for the determination of carbon dioxide in mineral carbonates. In all methods that have been devised for general usage, the material is decomposed by hydrochloric, less frequently by sulphuric acid, and the carbon dioxide evolved is weighed directly or by difference, measured by volume or absorbed and determined by titration. Any method which requires a purifying of the carbon dioxide before absorption is generally objectionable on account of the complicated apparatus and time required. To this class belong the methods of direct weighing in potash bulbs or a soda-lime tube. In the second class, embracing many but slight variations, in which the carbon dioxide is found by loss of weight, the operation and apparatus may be simple enough, but the results are not always accurate enough.

Considering the extent to which barium hydrate is used as the absorbent for carbon dioxide in other and similar determinations, it seems strange that it is not more generally used in the analysis of carbonate. It is very likely that some chemists do use it, though the writer is not informed of any published method recommending it. Barium hydrate has for many years had application in the determination of carbon dioxide in air, and many chemists prefer it in the determination of carbon in iron and steel by combustion, a scheme for its use having been worked out by A. G. Mckenna in 1895.* It may be said, as a matter of observation, that those who substitute barium hydrate for potash or soda-lime do not return to the old method. The writer has used the following method for determining carbon dioxide in limestone, dolomite and cement with excellent results, and is prepared to recommend it.

APPARATUS.

The accompanying sketch shows the arrangement of apparatus, which consists of a 250 c.c., low-form flask; a 30 cc., peat-shaped separatory funnel, a tall, gas-washing bottle, a Meyers' bulb tube, an iron burette stand and a Bunsen burner. Everything except the



Apparatus for Determination of Carbon Dioxide in Rock.

washing bottle is conveniently supported on the burette stand by means of two clamps set at right angles. Air is drawn through the apparatus by means of suction. An aspirator could, of course, be used instead, and would give a more even current of air, but there is no special advantage in this and the suction is more convenient.

PROCEDURE.

Having the apparatus in readiness, with some 20 per cent solution of potassium hydrate in the washing bottle, transfer 0.25 gram of limestone or dolomite to the evolution flask; insert the stopper with the separatory funnel and the glass, connecting tube; pour into the funnel tube a mixture of 5 c.c. of strong hydrochloric acid and 25 c.c. of water, and connect it with the washing bottle. By means of a rapidly flow-

* Proc. Eng. Soc. W. Pa., XI, 3.

ing pipette transfer 100 c.c. of a stock, two per cent solution of barium hydrate to the bulb tube, and insert the stopper immediately. Apply gentle suction from a filter pump, and when the pressure has been diminished in the flask, open the stop-cock and let the acid run in. Heat the liquid in the flask below the boiling point for 15 minutes, maintaining a current of air all the time, then boil for five minutes. Have ready an 11 cm. paper filter with slight suction and an aspirator bottle with recently-boiled water for washing the precipitate. In removing the bulb tube the back rush of the liquid may be prevented by leaving the suction on, closing the stop-cock of the funnel tube and then quickly removing the stopper from the bulb tube and placing the thumb over the mouth of the tube. Invert the bulb tube over the filter and allow the liquid to run through, regulating the flow by pressure of the thumb, and when the tube is empty quickly rinse it and the filter to remove the strong, active barium hydrate. By running a little water into the bulb tube and quickly inverting it the precipitate is readily flushed out. Six to 10 copious washings will free the filter and precipitate from barium hydrate. Ignite the precipitate with the precipitate and weigh as $BaCO_3$, containing 22.29 per cent CO_2. One of the titration schemes could be used instead of weighing the barium carbonate, but the gravimetric method is generally preferable.

The procedure in the analysis of cement is the same as the above, except that two grams of ordinary cement should be taken, and the acid in the mixture increased to 10 c.c.

A few suggestions regarding the handling of barium hydrate may be of service to those who have not had much experience with it. It may be conveniently made up in a quantity of two liters at a time and kept in a glass-stoppered bottle. If one liter of water is boiled, the barium hydrate added, and the other liter added cold the barium carbonate that is always present will settle within a few hours, and the clear solution can be siphoned into the stock bottle. This should be rinsed beforehand with carbonic acid-free water. If waiting for the precipitate to settle is undesirable the solution can be decanted through a large ribbed filter or through a suction pulp filter if most of the precipitate is kept back. The plan of allowing the precipitate to settle thoroughly and siphoning is recommended as being most satisfactory. It is well to make the solution a day at least before using any. Precipitate in the stock bottle does no harm if allowed to settle there, since the portions for use are withdrawn with a pipette.

Lafayette College, December, 1909.

In edge tools, it has been shown that vanadium steel has a much longer life than the best steel heretofore employed, as it retains the cutting edge longer, and owing to toughness, one of these tools seldom breaks.

THE ACTION OF ORGANIC SULPHUR IN COAL DURING THE COKING PROCESS.*

BY A. L. M'CALLUM, B. Sc., HALIFAX.

I was led to undertake this investigation by the conflicting statements of the authorities as to the action of organic sulphur during the coking process. Some say that the whole of the organic sulphur remains in the coke, others that part is volatilized, and still others that all the organic sulphur is driven off in the coking process. It is barely possible that all these statements are true of different coals, but I wanted, if possible, to find out what was the case with a typical Nova Scotia coking coal.

It occurred to me that if I could get a series of samples with a decreasing amount of inorganic sulphur and an increasing amount of organic, I would be able to get some data on the above subject, by determining the amount of inorganic and organic sulphur, and at the same time the amounts of volatile and fixed sulphur in the various samples.

It might be well at this point to say a few words as to the manner in which sulphur occurs in coal. To the best of our knowledge sulphur occurs in three forms in coal:—(1) as sulphates; (2) as iron pyrites; (3) as organic sulphur.

The coal used in this investigation was practically free from sulphates so that we have the two latter forms only to deal with.

The action of iron pyrites when subjected to heat without access of air is well known. There is loss of one atom of sulphur according to the equation $FeS_2 = FeS + S$. The coke oven presents ample time and the necessary conditions for this reaction to be complete.

Not knowing in what state of combination the organic sulphur occurs in coal, it is impossible to say what effect the heat of the coke oven will have. It was, as previously stated, in an attempt to throw some light on this question, that the investigation was undertaken.

Now to return to our coal samples; the only way to obtain such a series of samples as previously mentioned, viz.: with decreasing inorganic and increasing organic sulphur was to fractionate the coal on the basis of specific gravity. The means used to accomplish this were solutions of calcium chloride of varying specific gravities. The coal used was crushed to pass through 1-12 inch mesh screen and was then placed in a vessel containing a solution of calcium chloride of slightly higher specific gravity than that of coal.

For instance, the raw coal was found to have a specific gravity of 1.323. For this a calcium chloride solution of 1.35 specific gravity was used. This separated the coal into two fractions having the following specific gravities; the lighter material 1.275 and the heavier 1.731.

*From the Canadian Mining Journal, September 1, 1909.

Part of this lighter or floating fraction was reserved for analysis, and the remainder was treated with a calcium chloride solution of lower specific gravity. This procedure was kept up until, at a specific gravity of 1.24 there was no floating fraction.

Between these two extremes I obtained five fractions of the following respective specific gravities:

No. 1 1,323
No. 2 ..... 1.275
No. 3 1,261
No. 4 ..... 1.253
No. 5 ..... 1.243

The proximate analyses of these samples are as follows:

TABLE I.

	Volatile matter.	Fixed Carbon.	Ash.	Sulphur	Sulphur in Coke.
1	35.10	59.74	5.16	2.06	1.80
2	35.92	61.57	2.51	1.29	1.17
3	36.10	62.27	1.63	1.09	.85
4	37.47	61.50	1.04	.95	.78
5	37.75	61.35	.90	.88	.68

The only method at present available for the determination of the organic sulphur in coal is by difference, and there is one inherent source of error which, however, I think is not material. The method referred to is as follows: The percentage of iron is determined. Then this iron is combined with the necessary amount of sulphur to form iron pyrites (FeS_2). This amount of sulphur is deducted from the total amount in the coal and the balance is called organic sulphur.

The error referred to in this method is due to the fact that it is almost certain that there is some iron present as silicate in the "stone and shale" which are always present in the coal. But as the percentage of iron in the "stone and shale" rarely exceeds 3 per cent. and the percentage of stone and shale in the coal under consideration rarely exceeds 5 per cent. of the coal by weight, it will readily be seen that any error introduced will be exceedingly small.

Applying this method to the samples under consideration, we obtain the figures given in Table II.

TABLE II.

	Organic sulphur.	Inorganic sulphur.
1	37.86%	62.14%
2	56.59	43.41
3	71.56	28.44
4	83.16	16.84
5	85.23	14.77

We have thus clearly obtained a series of samples with gradually decreasing inorganic and increasing organic sulphurs.

There is also another way in which the total sulphur may be distributed, viz.: as volatile and fixed sulphur; meaning, of course, that sulphur which escapes during the coking process and that which remains in the coke. The method used in obtaining this information is to first determine the total sulphur in the coal and then the total sulphur in the coke produced from that particular coal. From this it is easy to calculate the amount of sulphur volatilized.

Table III gives the figures thus obtained.

TABLE III.

No.	Volatile sulphur.	Fixed. sulphur.
1	33.49%	66.51%
2	42.64%	57.36%
3	50.46%	49.54%
4	49.47%	50.46%
5	52.27%	47.73%

There is not the same regularity as shown in Table II, but there seems to be an increase in the amount of volatile sulphur in those samples having a high percentage of organic sulphur.

Now if the only sulphur volatilized was the one atom of sulphur in pyrites according to the above mentioned equation, we can calculate what the percentage of volatile sulphur should be; because the sulphur called inorganic is assumed to be present as iron pyrites. So that if we take half the inorganic sulphur it should correspond with the percentage of volatile sulphur if the above supposition is true, and also if there is no organic sulphur volatilized.

The result of this calculation is given in Table IV.

TABLE IV.

	One half the Inorganic sulphur.	Volitate sulphur.	Difference.
1	31.07	33.49	2.42
2	21.70	42.64	20.94
3	14.22	50.46	36.24
4	8.42	49.47	41.05
5	7.38	52.27	44.89

This would seem to indicate that when the inorganic sulphur was in excess the above supposition is approximately true, but that it does not hold at all when the organic is in excess. It seems rather strange why this should be so unless it is due to mass action.

I think we are perfectly justified in concluding that in the coking process a very considerable part of the organic sulphur is volatilized.

WORLD'S PIG IRON PRODUCTION.

The production of pig iron throughout the world last year according to English statistics was 47,459,000 tons. In this total the United States figured for 15,936,000 tons; Germany for 11,616,000 tons; Great Britain for 9,290,000 tons; France for 3,337,000 tons; Russia for 2,600,000 tons; Austria and Hungary for 650,000 tons; Belgium for 1,187,000 tons; Canada for 563,000 tons; Sweden for 554,000 tons; Spain for 373,000 tons; Italy for 110,000 tons; Japan for 43,000 tons, and other countries for 200,000 tons. In 1907 the world's production amounted to 60,000,000 tons.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

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NOTES AND COMMENTS.

The Largest Chimney in the World.

The new chimney at the Great Falls Smelter of the Boston and Montana Consolidated Copper and Silver Mining Co. was blown in January 14th. This chimney was topped out, however, Oct. 23d, 1908. It is 506 feet in height above the foundation, and is the largest, both in size and capacity, in the world. The smelter plant, which consists of reverberatory and blast furnaces, McDougal roasters and converters, has a capacity of 4,500 tons of ore per day.

The site chosen for the new chimney was 2,000 feet back of the furnace plant, the elevation here being 246 feet above the charging floor of the furnaces, writes Edwin Higgins in *The Engineering and Mining Journal.*

It was first determined to excavate to a depth of thirty feet for the foundation, but when twenty-two and one-half feet of depth had been attained it was determined by tests that it was necessary to go deeper. The ground in which the excavation was made is hard shale. The foundation consists of an annular mass, the circular inner edge of which is forty-seven feet in diameter at the bottom and the octagonal outer boundary 103 feet across flats at the footing level, tapering to sixty-four and eighty-one foot diameters at the top of the concrete. The foundation was constructed of 1-3-5 slag concrete. The sand and stone were obtained from the smelter furnaces. In the work of construction 5,200 barrels of cement, 2,000 cubic yards of sand and 4,000 cubic yards of slag were used. The cost of materials and construction was in the neighborhood of $50,000.

The chimney proper has an octagonal base forty-six feet high, with a taper of 8 per cent. Above this point the section is circular, the first 180 feet above the base having a taper of 7 per cent, the next 100 feet 4 per cent and the remaining 180 feet 2 per cent.

The chimney was built in twenty-three sections, nineteen of these being above the octagonal base. The thickness of the chimney wall varies from 66 inches at the base to 18½ inches at the top. The outside diameter at the base is 78½ feet and 53¾ feet at the base of the cap. The inside diameter at the base is 66½ feet; at the top, 50 feet. In the base of the chimney are four flue openings.

As a protection against the corrosive effects of the furnace gases the chimney is lined with four-inch radial perforated block, acid proof, installed in sections. Acid-proof mortar, made of silicate of soda, asbestos wool and other ingredients, was used. The chimney was first completed and the lining put in afterward. There is a two-inch air space between the lining and the chimney proper, and every precaution is taken to prevent the gases of metalliferous dust from entering the air space. In laying the cap for the protection of the top of the chimney from the action of acids which might form, special terra cotta blocks with interlocking sections were used. These blocks, or tiles, are laid in and pointed up with acid-proof cement mortar.

Protection against lightning is afforded by a lightning rod of sixteen points, which projects five feet above the top of the chimney. These rods are made of one-inch round copper, coated with lead and tipped with one and one-quarter inch platinum points. Encircling the chimney a few feet below the top is a horizontal copper ring, from which two five-eighths-inch stranded copper cables lead to the ground; this ring is connected to the lightning points. The copper ring and cables leading to the ground are coated with one-eighth-inch lead 100 feet from the two as a protection against acid. The copper cables leading to the ground terminate in three-foot ground plates, which are buried at a distance from the chimney.

On the outside of the chimney, built into the brickwork, is a ladderway consisting of one-piece rungs of three-quarter-inch round iron bars twelve inches wide.

REFINING STEEL IN THE MOLD ELIMINATION OF MECHANICALLY HELD IMPURITIES.

Along with the latest facts from practice and the weighty opinions of eminent metallurgists, George Auchy, of Philadelphia, gives his own views on the above subject in a recent contribution. His paper, which is quite a logical discussion, appeared in *The Iron Age* (85, 2, p. 108). The following is an abstract of Mr. Auchy's paper.

Partial Correctives Now in Use.

These, summed up, consist in holding open hearth steel in the ladle before pouring to give the impurities time to rise to the surface; Mathesin's method of keeping the top of the ingot hot by the use of thermit; the Riemer process, in which the top of the ingot is kept liquid by applying a blowpipe flame; Hadfield's process, in which an air blast and coal are used instead of the gas flame, and the processes of Krupp and Wellman, in which slow cooling is promoted by lining the molds with nonconducting material. Admitting the value of these processes, especially those of Riemer and Hadfield, in restricting segregation and piping they are not as effective as desirable.

In the crucible and electric processes the steel is

"killed" or allowed to stand some time before it is teemed, and the high quality made by these processes is attributed to their relative freedom from oxide, slag and gases. But "killing" in the crucible and then teeming does not prevent segregation, piping and blowholes.

Making Fthe urnace the Mold.

The one way to free steel from oxides, blowholes, gases, manganese silicate, sulphide and other slag, to prevent blisters, ghost lines and markings (except those that come from subsequent operations) is by "killing" in the molds. The steel must hold liquid after the deoxidizer is added in an electrically-heated and preheated, refractory-lined, iron mold, or a graphite mold if small, and in a reducing atmosphere for some time, in part at a temperature barely above, alternating with one barely below the solidifying point of the steel. This would give the mechanically mixed impurities time to rise to the surface. Afterward, to prevent segregation and piping, the heat playing on the outside of the small mold or on the top of the large one, must be gradually lowered, that at the top last in the first case, so that piping will be lessened and segregation prevented, after which, when the ingot is cold, the pipe may be altogether destroyed by remelting the extreme top of the ingot and again cooling gradually.

This would involve, on the one hand, an electric furnace of such a type that, as in the Stassno, the bath is not agitated by a current of electricity passing through it, or using, on the other hand, the old crucible principle, heating the crucible by electric arcs, and preferably, if not inevitably, using a basic lining to avoid the continuous reduction of silica from the crucible by manganese and carbon, and the consequent formation of carbon monoxide gas.

The points of difference in this process from the Stassno, on the one hand, and the old crucible process, on the other, would be: 1. The heat treatment. 2. The withdrawal of the steel from the furnace solid instead of liquid. 3. The elimination of molds and teeming. 4. A product absolutely free from oxide, blowholes, slag, segregation and piping.

The practical difficulties to be apprehended would be "stickers," cracked walls, diminished output and increased cost. The first and second would probably not be more serious than now. With regard to the third, it must be understood that operation would not have to be suspended until the charge had entirely cooled down; but as soon as the heat was turned off the furnace could be withdrawn from the overhanging cover and electrodes and a freshly charged one substituted. As to the fourth, the cost would be no greater than in the present auxiliary electric.

Preventing Segregation by Gradual Cooling.

The writer's belief that slow cooling prevents segregation is based on these facts: The experiments of Talbot (Jour. Iron and Steel Inst., 1905, vol. 2), and those of Huston (The Iron Age, July 4, 1906) and (Jour. Franklin Inst., vol. 165, No. 5), show that lateral segregation (the segregation from the outside) must be distinguished from vertical segregation—that from the bottom up. These two seem to be totally unrelated phenomena. The former is due to the solidification of the iron squeezing out the more fusible and still liquid iron carbide, phosphide, etc., toward the center, and the latter is due merely to gravity. Lateral segregation occurs, like the chill in a piece of chilled iron, only to a certain degree inward—about one-fourth of the way to the center of the ingot—and is obviously due to chill. Obviously also, it may be remarked, the chain of blowholes at this same distance from the sides and from the top and bottom is due to chill.

Coming now to the subject of vertical segregation, or better, "floatation," as Mr. Huston's term for it is: We see that the slower the cooling the higher the position of the segregate, apparently; and the writer nourishes the pleasing hope that in very slow cooling, along with the top cooling last, the segregate may take itself clean outside of the ingot, so to speak. This would indeed be a futile hope, if the upward rise was gradual. But we see that it is not gradual, but is a sudden jump at the middle or upper part, leaving the lower half or more of the ingot roughly uniform, except at the extreme bottom, where the chill exerts its influence in the same way as it does along the sides.

Proofs from Practice.

Some proofs from practice justify the above views. In the Riemer process (Iron and Coal Trades Review, 1904), although the only measure taken to prevent the sudden chilling of the surface of the ingot is the preheating of the mold, yet there is no lateral segregation and no blowholes except at the extreme top. Further support for the writer's views will be found in the experiments of Messrs. Talbot and Huston, above referred to.

The North Carolina Corporation Commission, which fully investigated the Southern Railway wreck in December, near Greensboro, N. C., in which 12 were killed, found that this was due to a "pipe" in a rail, this occurring in the manufacture, and which could not have been discovered by the railway company.

The break was directly over a small but sound oak tie. The rail, which had been cracked for some time its entire length, was made by a Tennessee company. An interesting question arises whether a railway has recourse against a rail manufacturing company.

Vanadium appears to have three effects on the other metals with which it is combined—toughening, strengthening and scavenging. A certain proportion of it added to copper means an amazing increase in tensile strength. Added to bronze-bearing metal, it improves its elasticity and comprehensive strength. In cast-iron, it lengthens the life of the metal more than three-fold.

CHEMICAL SOCIETIES.

American Institute of Chemical Engineers.

The second annual meeting of the American Institute of Chemical Engineers was held in Philadelphia December 8 to 10, 1909. All the sessions were held in one of the parlors of the Hotel Walton.

The meeting began Wednesday morning at 10 a. m. with an address of welcome by the mayor's private secretary. This was responded to by President Sadtler. The reports of various committees were also read at this session. The most interesting of these was that of the committee on membership, which suggested that a grade of junior membership be established.

In the afternoon excursions were made to the plant of the Harrison Bros. & Co., to the laboratories of the University of Pennsylvania and to the Commercial Museum of Pennsylvania. At the works of the Harrison Bros. & Co. the members were served luncheon, after which they were shown the manufacture of paints, alum, sulphuric acid, etc.

At the evening meeting, President Sadtler read his address as retiring president, which is published elsewhere in this issue. This was followed by an interesting talk by Prof. Chas. E. Munroe on "The Chemical Industries of America."

Thursday was devoted entirely to excursions. In the morning the members visited the Torresdale Filtration Plant and the wool degreasing plant of Erben, Harding and Company. In the afternoon they visited the works of the Welsbach Light Company and the Camden Coke Company. At the former of these plants a delightful luncheon was served. The city boat, "S. H. Ashbridge," conveyed the members to the various points. In the evening a subscription dinner was served at the Hotel Walton.

The session Friday morning was devoted to the installation of officers, and the transaction of other business. Four papers were also read at this session. In the afternoon the members left for Trenton, where they visited the Trenton potteries, the Hamilton Rubber Company and linoleum works. The evening session was devoted to the reading of papers and to final business.

On Saturday a few of the members visited the plant of the Coplay Cement Company at Coplay, Pa.

The following officers were elected for the ensuing year: President, Dr. Chas. F. McKenna, New York; first vice-president, Dr. F. W. Frerichs, St. Louis, Mo.; second vice-president, Dr. Edward G. Acheson, Niagara Falls, N. Y.; third vice-president, Dr. Eugene Haanel, Ottawa, Canada; secretary, Dr. John C. Olsen, Brooklyn, N. Y.; treasurer, William M. Booth, Syracuse, N. Y.; auditor, Henry S. Renaud, New York. Directors for one year, Geo. B. Adamson, Easton, Pa.; David Wesson, Montclair, N. J.; Dr. Edward Gudeman, Chicago, Ill. Directors for two years: Ludwig Reutler, Berkeley, Cal.; Thorn Smith, Portland, Mich.; H. F. Brown, Wilmington, Del. Directors for three years: Dr. William M. Grosvenor, New York; Richard K. Meade, Easton, Pa.; Dr. S. P. Sadtler, Philadelphia, Pa.

The following papers were read:

"Natural Draft Gas Producers and Gas Furnaces," Ernest Schmatolla; "The Commercial Extraction of Grease and Oils," W. M. Booth; "Multiple Effect Distillation," F. J. Wood; "The Advantages of the Multiple Effect Distillation of Glycerine and Other Products," A. C. Langmuir; "Reclaiming of Waste India Rubber," S. P. Sharples; "Materials for Textile Chemical Machines," Frederick Dannerth; "A Method for Smelting Iron Ore in the Electric Furnace," Edward R. Taylor; "Chemical Composition of Illinois Coal," A. Bement; "Heat Efficiency of Smokeless Combustion and Heat Absorbing Capacity of Boilers," A. Bement.

Western Association of Chemists and Metallurgists.

The fifth general meeting of the Western Association of Chemists and Metallurgists was held at Boulder, Golden and Denver, Colo., Jan. 6, 7 and 8, 1910. The headquarters of the association during the meeting were at Denver.

On Thursday the members visited the beet sugar factory at Longmont, returning to Boulder. Luncheon was then served, after which papers were read.

On Friday the members visited Coor's brewery at Golden, and later the laboratories of the Colorado School of Mines. At 6 o'clock a complimentary supper was served at the latter institution, following which papers were read.

On Saturday the local committee had arranged for visits to various points of interest in and around Denver.

American Society of Chemical Engineers.

The forty-first meeting of this association was held in Boston, December 27th to 31st, 1909. The following list of papers were read before the division of Industrial Chemists and Chemical Engineers: "Practical Corrosion Tests of Iron," W. D. Richardson; "Methods for Testing Commercial Anydrous Liquid Ammonia and Results," W. D. Richardson; "Paint Films as Accelerators to Corrosion of Iron," W. H. Walker; "A Convenient Method of Refrigeration for Analytical and Industrial Investigations at Low Temperatures," James Otis Hardy; "Losses in the Storage of Coal," Horace C. Porter; "A New Precision Centrifuge," H. E. Howe; "The Determination of Oil in Flaxseed Products by the Specific Gravity Method," Charles H. Herty; "The Temperatnre Reaction of Oil Mixtures With Sulphuric Acid," W. H. Boynton and H. C. Sherman; "A Comparison of the Accuracy of Different Formulæ for Calculating Food Values," H. C. Sherman and D. A. Bartlett; "Action of Liquid Anhydrous Ammonia on Rubber Gaskets," Charles H. Ehrenfield; "Simple Viscosimeter," Chas. S. Palmer; "Lubricants and Lubrication." C. F. Mabery; "The Oxidation of Iron and Steel and How to Prevent It," J. S. Staudt; "Bacterial Activity as a Corrosive Influence in the Soils;" "The Effect of Non-Metallic Impurities on the Properties of Steel."

TRADE LITERATURE.

The Bristol Company, Waterbury, Conn. "Bristol's Recording Gauges for Pressure and Vacuum." A 47 page catalogue and a most complete list of this line of the Bristol Company's standard instruments. The illustrations and text are in keeping with their recognized excellence.

Dings Electro Magnetic Separator Co., Milwaukee, Wis. "Magnetic Separators." This bulletin describes in detail a highly developed type of separator, adapted to the treatment of widely differing classes of ores. Both mill and laboratory sizes are described

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The Havana Exploration Co., Ltd., of London, England, and Havana, Cuba, is developing a large asphaltum deposit in Cuba, located near the port of Mariel, some 30 miles from Havana. The deposit covers an area of over 2,200 acres, lying at a depth of 5 ft. to 20 ft. below the surface. It is said that borings have shown a thickness of over 300 ft. Asphaltum has been taken from this deposit at the rate of 10,000 to 15,000 tons a year for some time, and has been marketed in St. Louis and Chicago. The company above named, which secured control of the property a year ago, has installed a new plant and machinery and is stripping the surface soil with a long-boom excavator furnished by The Browning Engineering Co., of Cleveland. With this plant installed, it is claimed that an output of 200,000 tons of asphaltum can be reached during the present year. The asphaltum is said to give excellent results in paving compositions and to withstand extremes of temperature particularly well. The company has built a railway line from the mines to the harbor, and will erect wharves and loading facilities.

Magnesite for use in the manufacture of liquid carbon dioxide should be high in magnesium carbonate. The commercial mineral frequently contains as much as 98 per cent. In burning a charge of 90 per cent of high grade magnesite mixed with 10 per cent coke, 50 per cent of the weight of the magnesite is obtained in the form of carbon dioxide. The price of liquid dioxide depends upon the use to which it is to be put, the maximum price being about 10 cents per pound. However, the price is very variable and must be determined by negotiation. About 48 per cent of the weight of the magnesite remains as residue in the kiln, plus the weight of the ash of the coal or coke used. Coal or coke may be used as fuel. In the case of coke, the requirement is about 10 to 12 per cent of the weight of the magnesite. The value of calcined magnesite is $14 to $15 per 2,000 pounds.

The production of copper in 1909 reached 1,410,000,000 lbs. Of this amount 700,000,000 lbs. were consumed and 675,803,000 lbs. exported.

RECENT INVENTIONS.

The following patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill Building, 908 G Street, N. W., Washington, D. C.

938,505. Manufacture of *Paints*. Robert S. Perry, Cave Spring, Ga. November 2, 1909.

This is a rust inhibiting vehicle for paint or the like, consisting of a chromium base combined with an organic acid radical, such compound being freely linseed-oil-soluble, but not freely water soluble.

938,581 *Carbide* and Method of Manufacturing Same. Herman L. Hartenstein, Constantine, Mich. November 2, 1909.

The process comprises producing molten carbide and gradually drawing off the molten carbide and accumulating it in the form of block or ingot, the carbide being agitated while accumulating.

938,634. *Metallurgical Process*. Anson G. Betts, Troy, N. Y. November 2, 1909.

This is a process of making aluminum by reducing aluminum oxide in presence of other suitable less, reactive metal, producing thereby an alloy of aluminum with a less-reactive metal, reacting on the alloy with a suitable material capable of producing therewith an aluminum compound practically free from compounds of more readily-reducible metals than aluminum, and reducing aluminum from said aluminum compound.

938,698. Method of *Rejuvenating Asphalt*. James A. W. Pine, New York, N. Y. November 2, 1909.

This is a method of rejuvenating asphalt, wherein the cementitious properties of the bitumen have become exhausted or devitalized in whole or in part through chemical action or by causes other than injury due to abrasion, consisting in heating a mass of said asphalt to a temperature of between 300° and 400° F. under conditions which allow the heat to penetrate uniformly throughout the mass, whereby the asphalt is restored to an elastic and tenacious consistency equal to that of fresh asphalt.

938,732. *Roasting Separation Process*. Henry A. Wentworth, Newton, Mass. November 2, 1909.

The process consists in separating zinc sulphide from other sulphides associated therewith by superficially changing sulphides other than zinc sulphides by subjecting the mass to heat, and thereafter separating by flotation, the heat-affected particles from those unaffected.

938,758. Method of Manufacturing *Calcium-Silicon Alloys*, etc. Hans Goldschmidt and Otto Weil, Essen-on-the Ruhr, Germany. November 2, 1909.

This is a process of increasing the amount of alkaline earth metal in alloys of silicon with alkaline earth metals by melting same with iron.

938,779. Process of *Purifying Water*. James W. Morrison, Batavia, N. Y. November 2, 1909.

The process consists in heating the water under pressure to a temperature in excess of 300° F. so that its contained normally soluble matters become insoluble and precipitable, and then while they are in their highly heated insoluble condition under pressure, removing said insoluble matter by filtration.

938,877. Process for Producing *Translucent Paper*. Henry Kuhn, Rochester, N. Y. November 2, 1909.

The process consists in making a parchment paper from a paper made with cotton fiber, washing and drying said parchment paper, treating said paper with a fatty substance to render it translucent, subjecting such parchment paper to a high pressure and subsequently dimming said paper.

938,919. Method of Manufacturing *Gas*. Cornelius B. Tully, Wood Green, London, England. November 2, 1909.

The method consists in the blowing up or preliminary stage, in raising the lower ignited portion of a mass of fuel to a

state of incandescence by blowing air through it, burning some of the resulting combustible gases to heat an upper portion of the mass of fuel to a high temperature without allowing the burning gases to come in contact with such fuel and simultaneously supplying liquid hydro-carbon to the top part of the upper highly heated portion of the mass of fuel.

938,987. Process of *Burning Lime* and Apparatus Therefor. Henry L. Doherty, New York, N. Y. November 2, 1909.

The process consists in contacting with ignited carbon, a portion of the gases produced in the calcination of the limestone, mixing with the combustible gas so produced, another portion of the gases from the calcination of the stone, heating air by contacting the same with the hot lime, and burning said gas mixture with said heated air in contact with said limestone, the portion of calcination gasses added to said combustible gas, being such that the temperature developed in the burning of said gas is below that at which the impurities in the stone will combine chemically with the lime.

939,014. Art of *Coloring Wood*. William A. Hall, New York, N. Y. November 2, 1909.

This is a process of producing variegated colored wood, consisting in treating the wood, in a closed receptacle, and with the aid of vacuum and high pressure, with a solution comprising ingredients of different capillary activity or different penetrating qualities.

939,078. Process of Making *Cement* and Other Products. Samuel Peacock, Chicago, Ill. November 2, 1909.

This is a process of making free pentoxide of phosphorus, P_2O_5, and Portland cement in a single operation from phosphate rock, which consists in providing a rock mixture in which the ratio of the total silica SiO_2, to the total alumina and ferric oxide is greater than 2 and less than 4; and in suitably treating said mixture to form Portland cement and to separate and recover the P_2O_5.

939,183. Process of *Generating Electricity*. Henry S. Blackmore, Mt. Vernon, N. Y. November 2, 1909.

The process consists in generating electricity, by employing a molten electrolyte having in communication therewith electrodes one of which is more electro-positive than the other and contains metal carbid decomposable by the electrolyte, the said electrodes being separated from each other by a body of the erectrolyte.

939,217. Manufacture of *Cement*. Sherard O. Cowper-Cowles, Westminster, London, England. November 9, 1909.

The process which consists in fusing a mixture of the ingredients from which the cement is formed, and then subjecting the fused mass to the action of an electric current and further raising the temperature of the mass to bring about certain reactions and set free the sulphtur.

939,223. Process for *Electrolytically Removing Iron Oxide Scale*. Charles W. Danforth and Noble Jones, Sharon, Pa. November 9, 1909.

This is a process of electrolytically removing iron-oxide scale from the surface of iron and steel, which consists in subjecting same as cathode to the action of an electric current, while submerged in a solution containing bisulfate of an alkaline metal in water.

939,413. Process of *Assaying for Silver*. Joseph C. Hames, Goldfield, Nev. November 9, 1909.

The process consists in adding to a quantity of ore pulp, camphor, iodine, potassium iodide and a solvent, adding sodium cyanide, precipitating the silver in the solution from the assay on zinc, dissolving the precipitated silver in nitric acid, adding starchy matter to the solution, and determining the amount of silver in the solution.

939,494. *Solder for Aluminum*. Louis Goppman, Pittsburg, Pa. November 9, 1909.

The solder consists of a composition of tin, 49.05%, antimony 3.43%, lead 26.06%, zinc 20.31%, and copper 1.10%.

93,570. Composition of *Matter for Generating Heat*. Frank J. Tone, Niagara Falls, N. Y. November 9, 1909.

The composition is a mixture of finely-divided metal containing substance, a normal oxygen compound of an element having less affinity for oxygen than is possessed by the metal, and a highly oxidized unstable oxygen compound.

939,646. *Lubricant*. James W. Watkins, Zanesville, Ohio. November 9, 1909.

The lubricant is formed by bringing together soap, graphite, ammonia, mineral machine oil, tallow, common salt and water.

939,733. Method of *Bleaching Rosin*. Lawrence C. Minor, Cincinnati, Ohio. November 9, 1909.

The method consists in the artificial production of ultra-violet light rays and subjecting melted rosin to the action of said rays.

939,742. *Treatment of Quebracho Extract*. Albert Redlich and Julius Wladika, Vienna, Austria-Hungary. November 9, 1909.

The process which consists in mixing the hot liquor obtained by diffusion from the quebracho wood with an alkali, heating the mixture directly with exclusion of air, adding a quantity of acid equivalent to the quantity of alkali used, cooling the resultant mixture, to precipitate the resinous matter, and drawing off the clear liquor.

939,930. Composition of *Matter for the Generation of Heat*. Frank J. Tone, Niagara Falls, N. Y. November 9, 1909.

The composition consists in a mixture of finely divided metallic silicon with an oxidizing compound of an element having less affinity for oxygen than is possessed by silicon, said composition having the property of self-propagating reaction when ignited locally by external means.

939,938. *Composition of Matter*. Charles F. Ackerman, Cleveland, Ohio. November 9, 1909.

The composition contains copper, zinc, nickel and lead, together with relatively small quantities of arsenic and aluminum.

939,947. Treatment of Copper or *Copper-Nickel Mattes*. James T. Carrick, Johannesburg, Transvaal. November 9, 1909.

The process consists in digesting matte in acid, recovering substantially pure cuprous sulphide and bessemerizing such cuprous sulphide with the use of extraneous gaseous or vaporous fuel.

939,977. *Cementitious Composition* and Process of Making the Same. William E. Carson, Riverton, Va. November 16, 1909.

The composition comprises a directly produced basic aluminate of calcium hydrated to a point short of complete hydration and setting and forming a dry hydrated powder.

939,980. Process of Making *Acetates*. Harry O. Chute, Cleveland, Ohio. November 16, 1909.

The process consists in fractioning out concentrated wood alcohol and accompanying volatile impurities from pyroligneous acid, distilling the residual acid and saturating the acid in the vapors with a base at a temperature above the boiling point of water.

940,111. *Flux for Use in Soldering*. Wilhelm Ackermann, Berlin, Germany. November 16, 1909.

A hard solder flux consists of three to four molecules of boracic acid, one molecule of an alkali, and water.

940,181. Process for *Treating Tobacco*, etc. George Montag, Mannheim, Germany. November 16, 1909.

The process consists in extracting the juice from green unfermented tobacco in a cold state by means of pressure, saturating leaves to be treated with said juice and then heating the saturated leaves.

940,289. Process of Manufacturing *Mixed Coal-Gas and Carbureted Water-Gas*. Walter Thomas, Vancouver, British Columbia, Canada. November 16, 1909.

The process consists in partly distilling coal in an inclined or horizontal body and freely conducting off the resulting gas without passage through coke for retaining volatile illuminants, pushing the partly distilled coal into a vertical body

and completing the distillation, at suitable intervals spraying hydrocarbon oil into the distilling retort and passing the resulting vapor and gas down through the incandescent coke for converting them into fixed enriching gas, and passing such gas off at the base, and mixing it with the coal gas.

940,292. Method of *Separating Copper, Nickel and Other Metals from Copper-Nickel Matte.* Horace L. Wells, New Haven, Conn. November 16, 1909.

The method consists in pulverizing the matte and agitating it with hydrochloric acid solution heated below the boiling point and containing not more than 25% of actual hydrochloric acid, the solution resulting containing the nickel and the solid residue resulting containing the copper.

940,450. Process of Manufacturing *Composition Boards.* Johann Ferla, St. George, N. Y. November 16, 1909.

The process consists in first making hydraulic cement and fibrous material in the dry state, and then adding to the dry mixture glue, an acid solvent for glue and water in sufficient quantity to make the material flow readily, next forming layers from the mixture, then pressing the layers and finally allowing the pressed layers to set or harden.

940,580. *Explosive.* Clarence U. Buck, Wellsboro, Pa. November 16, 1909.

This is a process of preparing an explosive compound which consists of fusing a mixture of tri-nitro-phenol, dinitro-phenol and a nitro-carbo-hydrate and then raising the temperature to about 350° F.

940,595. *Purification of Burner-Gases.* John B. F. Herreshoff, New York, N. Y. November 16, 1909.

This is a process of purifying gases containing SO_2, which consists in bringing the gases into contact with a minutely distributed body of weak acid containing absorbed SO_2 and exposing them to the action of such acid until the solid impurities have been practically eliminated, and then removing non-solid impurities by filtration.

940,665. Method of *Treating Iron or Steel.* Frederick M. Becket, Niagara Falls, N. Y. November 23, 1909.

The method consists in incorporating with the molten metal an alloy containing more than five per cent each of titanium and silicon and less than ten per cent of carbon, said alloy being relatively fusible as compared with metallic titanium and titanium carbid.

940,821. Process of *Treating Ores.* John R. Parks, Spokane, Wash. November 23, 1909.

The process consists in intermixing pulverized ore, cyanide of potassium and an electrolyte and simultaneously passing a current of air and a current of electricity through the mixture, passing such mixture through each of a series of electro-cyanide pans, and excluding any one of said pans from the series while the mixture continues to pass through the other pans.

940,848. Process of *Preserving Edible Substances.* Arthur J. Baldwin, East Orange, N. J. November 23, 1909.

The process consists in maintaining such substances under the pressure of a gas to destroy the living and inhibit the development of the bacteria therein, and then subjecting the substances to a vacuum for removing the foreign flavor acquired by the absorption or presence of the gas, as set forth.

940,898. Process of *Detinning Tin-Plate by Means of Chlorine.* Hans von Schutz, Wetzlar, Germany. November 23, 1909.

The process consists in completely drying tin-bearing material and then subjecting it to the action of chlorine gas, the gas being below normal temperature.

941,339. Process of Producing *Silicon Carbide.* Frank J. Tone, Niagara Falls, N. Y. November 23, 1909.

The process consists in embedding a resistance-conductor consisting of a linear series of separate shaped resistance-pieces of predetermined cross-section and resistance arranged in direct electrical contact, and passing an electric current through said conductor.

Abraham Wynberg, Amsterdam, Netherlands. November 941,401. *Wax-Like Product* Obtained *from Sugar-Cane.* 30, 1909.

The product consists of a composition of a wax-like compound and of fat-like compound obtained by the treatment of the residues of the sugar-cane manufacture, the wax-like compounds having a melting point 60-91° C., acid number 1-10, saponification number 6-11, acetyl number 77-95, and the fat-like compounds having a melting point of 35-55, acid number 10-40, saponification number 120-212, iodin number 19-68, acetyl number 15-47.

941,477. Method of *Treating Armor-Plate.* Samuel S. Wales, Munhall, Pa. November 30, 1909.

This is a method of making armor of ballistic steel plates, consisting in producing a steel plate, heating the plate to a temperature above 875 degrees C., and suddenly cooling it to between 450 degrees C. and 100 degrees C., and then annealing the plate.

941,553. Process of Producing *Low-Carbon, Low-Silicon Titanium Alloys.* Frederick M. Becket, Niagara Falls, N. Y. November 30, 1909.

The process consists in producing low-silicon tinanium alloys by producing a high-silicon alloy and oxidizing out the contained silicon.

941,585. Method of Producing *Insulating Bodies.* Valentin A. Noodt, Hamburg, and Georg Gottsche, Altona, Germany. November 30, 1909.

The method consists in preparing a liquid binding medium, adding thereto sufficient foliated charcoal to take up the liquid, stirring the mass only until the foliated charcoal assumed a splinter formation, and then compressing the mass thus formed sufficiently to produce a porous body.

941,799. Manufacture of *Alumina.* Gilbert McCulloch, East St. Louis, Ill. November 30, 1909.

This is an improvement on the process of manufacture of alumina by the alkaline process wherein the alumina is precipitated from a solution of sodium aluminate by CO_2 gas, which consists in arresting the precipitation after a large proportion of the alumina has been precipitated from the solution, whereby a large proportion of the contained silica is retained in the solution.

941-835. *Aluminum-Solder.* John Wirgovits, New York, N. Y. November 30, 1909.

The alloy is composed of over sixty per cent tin, less than thirty per cent zinc, and a small per cent of copper.

941,901. Process for *Treating Certain Ores.* Herbert S. Auerbach, New York, N. Y. November 30, 1909.

This is a method of reducing an ore soluble in fused lead, which consists in forming a body of fused lead, resting a fused electrolyte upon said body of fused lead, adding directly to said body of fused lead an ore soluble therein, meanwhile preventing the direct contact of said ore with said fused electrolyte, and finally passing an electric current through both said fused electrolyte and said body of fused lead, said body of fused lead serving as a cathode.

Byproduct coke ovens have for some years been the leading producers of ammonia in the states. This is sold in the form of crude ammonia liquor, sulphate of ammonia, and aqua ammonia. The first named is an impure solution of the ammonia gas in water, containing some light tar oils, sulphur compounds, carbonates, etc., and contains from 15 to 25 per cent of ammonia. It is used in the ammonia soda industry, and also as a raw material for manufacturing higher grades of ammonia, such as the nitrate and carbonate of ammonia, etc.

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TREATING TIMBER WITH CRUDE PETROLEUM.[1]

With one or two exceptions it has not been possible as yet to formulate any definite results on the treatment of wood, in which crude petroleum (or combinations of it with other things) have been used. It is, therefore, only within my power to give a short resume of the status of the crude petroleum treatments.

It has been only recently that treatment of timbers with crude oil has been undertaken commercially. Two railways have adopted it. The National Lines of Mexico, at Aguascalientes, and the Atchison, Topeka & Santa Fe Ry., at Albuquerque, N. M. The former is using the Mexican crude oil, and the latter gets its supply from Bakersfield, Cal.

As yet it is purely an assumption, as to the probable results of this kind of treatment, because it is radically different from all past deductions as to the preservation of timber. Heretofore it has been considered essential to have in the preservative medium, an element that was either germicidal or antiseptic in its nature. This new treatment is depending upon an entirely new conception of preservation, namely, the elimination of air or oxygen and moisture. This has for its basis the well-known fact that in order that fungi may thrive, there must be present three essential conditions: moisture, air or oxygen, and the proper temperature.

Therefore, this crude oil treatment gets its impetus from the fact that it probably will be (1) a weather-proofing agent, as the tie is thoroughly impregnated with the oil, and (2) that the fungi will not be able to thrive, from the presence of any moisture which may have been left in the timber previous to treatment, due to the absence of oxygen or air.

The various crude oils which are in use either commercially or experimentally, have been examined as to their germicidal or antiseptic properties, and from all known tests covering such work, none of them contain any such properties.

The first oil to be used in the United States commercially was the Bakersfield oil. Timbers treated with this oil have been in the experimental track of the Gulf, Colorado & Santa Fe Ry., near Pelican, Tex., for over three years, and some ties taken out recently for examination were entirely free from all indications of decay. This is promising, though not convincing, that the treatment has its merits; that it will preserve the tie for its mechanical life.

Recently the Santa Fe Ry. has investigated other oils, more especially a Mexican oil from Ebano. Another oil from Oklahoma has been tried. (The characteristics of these oils are summarized in the accompanying table.—Ed.)

Pine has been the principal wood used in the experiments. The gums required a considerable longer time and a higher pressure. Using Ebano oil on gum ties, one experiment gave an absorption of 55 lbs. per tie, yet the ties were somewhat checked from being subjected to such a high pressure (175 lbs.) and a high temperature (200° F.).

There is, apparently, no difficulty in thoroughly impregnating all the sap wood of the different species of pine. In the case of the loblolly, it is thoroughly saturated. All the sap of the shortleaf and some of the heart receive treatment, while with the long-leaf, the penetration is confined entirely to the sap wood.

With creosoted ties, it is not unusual to find that after they have been air-seasoned a year after the treatment they weigh less than they did when treated. Such is not the case with the crude oil treatment. Seasoning tests with the three oils gave the following tie results, after seasoning ten months: 27 ties treated with Bakersfield oil lost an average of 2.6 lbs. each; 30 ties treated with Oklahoma oil lost an average of 14.3 lbs. each; 30 ties treated with Ebano oil lost an average of 14.4 lbs. each.

The crude oils are viscid at ordinary temperatures, but do not affect pipe lines during treatments. The oil is used at a temperature varying from 175° to 200° F.

Checking seems to be reduced to a minimum with this treatment, except in a few cases where it was necessary to use great pressure and high temperatures. On standing, any small checks that are formed, become filled with the oil, which forms a plug against the entrance of any moisture. On seasoning the ties after treatment, the oil has a tendency to form a coating on the outside. This forms a very insoluble covering to the whole tie, very much like the theoretical leather

[1]Abstract of a paper read at the annual meeting of the Wood Preservers' Association, at Chicago, Jan. 19, 1910, by C. Marshall Taylor, Chief Department of Chemistry and Tests, International Creosoting & Construction Co., Texarkana, Tex.

formation which was supposed to form in the Wellhouse process.

The Ebano oil does not mix with thinner crude oils, as it becomes coagulated, forming a stick mass. At the outset of this treatment, two objections were suggested: (1) The ties would be inflammable, and (2) the spikes would be liable to work loose. Both of the objections never existed in actual practice, and no such conditions exist among ties treated with these crude oils.

The success of this treatment depends upon the fact that all the sap wood must be thoroughly impregnated and with all the oil that it is possible to force into them.

The National Ry. of Mexico has not much doubt that the Mexican pine ties will last their mechanical life, which they figure will be about five or six years when treated. They figure the cost to be less than 20 cts. (Mexican currency) per tie, and will answer their special requirements, if they get five or six years' life.

CRUDE OILS USED IN TIMBER PRESERVATION.

Oil.	Bakersfield (Cal.)	Oklahoma.	Ebano (Mex.).
Appearance	Dark, viscid.	Brown, syrupy, with green fluorescence.	Black, viscid.
Odor	Asphalt.	Sour petroleum.	Asphalt and sulphur.
Spec. gravity	0.965 at 38° C.	0.902 at 21° C.	0.918 at 60° C.
Distillation (p. ct.):			
Below 210° C.	.....	.....	2.07
210° to 235°	1.1	.....	1.77
235° to 270°	1.5	1.2	3.48
270° to 315°	6.7	3.4	6.01
315° to 355°	14.5	13.6	18.66
Residue, per cent	75.2	81.8	65.30
Residue, character	Black, thick, viscid.	Viscid, dark brown.	Black, sticky.
Boils at	70° C.	120° C.	110° C.
Loss by evaporation after 12 mos. exposure in open vessel	None.	No tests.	7%

THERMIT WELDING.

The property which aluminum has of keeping molten metal hot or of raising the temperature of a molten metallic bath has been utilized in the thermit welding process, invented by Goldschmidt. In this process aluminum and iron oxide are intimately mixed in a finely divided state and ignited by means of a fuse. The heat of combustion in the ensuing reaction raises the temperature of the casting to the welding point. The reaction takes place in a funnel-shaped crucible, from which the fluid metal resulting from the reaction is run into a suitably shaped mold formed around the area of the joint to be made, which is preheated by means of a blow lamp to avoid chilling the first lot of metal coming through.

The total mineral production at Cripple Creek, Colo., in 1909 is figured at $15,850,113.

CLEANING DISCOLORED MARBLE.

By F. P. DUNNINGTON.

Frequently when marble is exposed, as in a cemetery, where it is more or less sheltered by trees, it is disfigured by lichens and other vegetable growth.

In many instances this growth has died and become brown or black in color. All such discolorations may be readily removed by soda lye of moderate strength, about 5 per cent. That which is rotted is dissolved and the remainder is soon disintegrated.

The following directions answer well: A box of concentrated lye, containing about twelve ounces of caustic soda is dissolved in a two-gallon bucket of water. Spread this over the stone with a small cheap scrubbing brush, made with vegetable fiber, preferably provided with a handle so as to avoid getting the lye upon the hands, the clothes or the shoes. After ten minutes or more pour water over the stone to wash off most of the lye and then rub it a little with the brush, using some sand if necessary, and the stains will be removed.

Of course this liquid has no effect upon the stone itself and is most easily washed away. So far as the wash falls upon the ground, it will improve rather than harm any grass or other plants. Should the lye remain upon the skin, it may occasion an ugly sore. If splashed upon the clothing, the prompt application of a solution of sal ammoniac will prevent corrosion of the goods.

University of Virginia, January, 1910.

Asbestos is a fibrous mineral, varying from a short, stiff, coarse fiber to a long, soft, hairlike fiber, which is easily separated by the fingers and has much the appearance of flax.

No chemical tests are necessary to identify asbestos. It may be distinguished by its appearance and its infusibility. It occurs in commercial quantities in Georgia, California and Wyoming, and is generally found associated with soapstone. The best long fiber asbestos is worth from $275 to $325 per ton, while the short fiber brings as low as $25.

THE APPROXIMATE COST OF MILL BUILDINGS.*

By CHARLES T. MAIN,† M. AM. SOC. M. E.

It is sometimes convenient to be able to tell off-hand the approximate cost of proposed buildings, or the cost if new, of existing buildings without going through an estimate of all the quantities of materials and labor. If is not an uncommon thing to hear the cost of mill buildings placed from 70 cts. to $1 per sq. ft. of floor space, regardless of the size or number of stories. There is, however, a wide range of cost per square foot of floor space, depending upon the width, length, height of stories and number of stories.

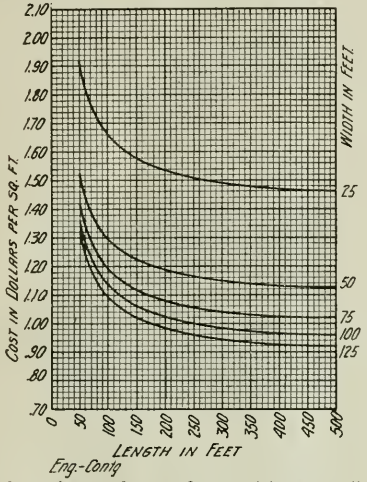

Fig 1—Cost Diagram for One-Story Brick Mill Building.

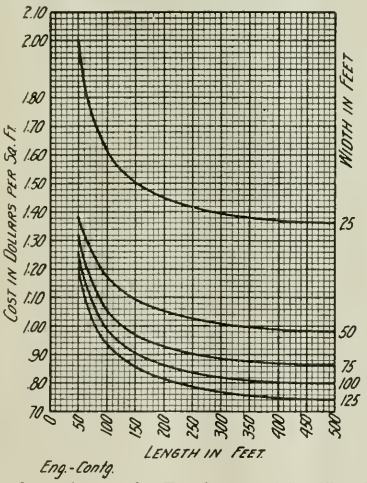

Fig. 2—Cost Diagram for Two-Story Brick Mill Building.

Some time ago I placed a valuation upon a portion of the property of a corporation, including some 400 or 500 buildings. In order to have a standard of cost from which to start in each case, I prepared a series of diagrams showing the approximate costs of buildings varying in length and width and from one story to six stories in height. The height of stories also was varied for different widths, being assumed 13 ft. high if 25 ft. wide, 14 ft. if 50 ft. wide, 15 ft. for 75 ft., 16 ft. for 100 ft. and over.

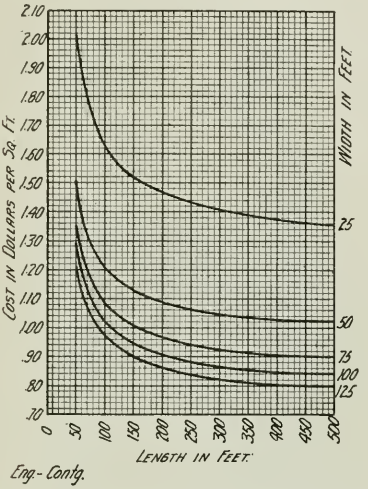

Fig. 3—Cost Diagram for Three-Story Brick Mill Building.

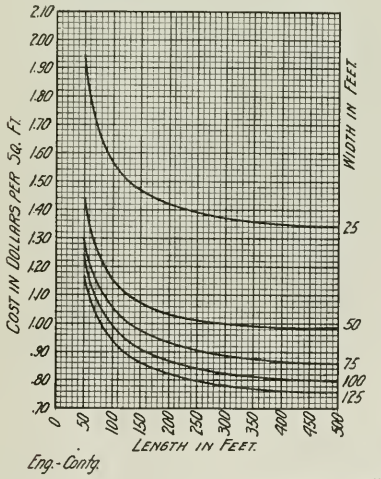

Fig. 4—Cost Diagram for Four-Story Brick Mill Building.

The costs used in making up the diagrams are based largely upon the actual cost of work done under average conditions of cost of materials and labor and with average soil for foundations. The costs given include

*Paper presented before the New England Cotton Manufacturers' Association, April, 1904, revised to conform with prices prevailing about January, 1910.

†Mill Engineer and Architect, 201 Devonshire St., Boston, Mass.

plumbing, but no heating, sprinklers, or lighting. These three latter items would add roughly 10 cts. per sq. ft. of floor area.

USE OF DIAGRAMS.

ESTIMATES.—The accompanying diagrams can be used to determine the probable approximate cost of proposed brick buildings, of the type known as "slow-burning" to be used for manufacturing purposes, with a total floor load of about 75 lbs. per sq. ft. and these can be taken from the diagrams readily. The curves were derived primarily to show the estimated cost per square foot of gross floor area of brick buildings for textile mills, and to include ordinary foundations and plumbing. For example, if it is desired to know the probable cost of a mill 400 ft. long by 100 ft. wide, three stories high, refer to the curves showing the cost of three-story buildings. On the curve for buildings 100 ft. wide, find the point where the vertical line of 400 ft. in length cuts the curve, then move horizontally along this line to the left-hand vertical line, on which will be found the cost of 81 cts.

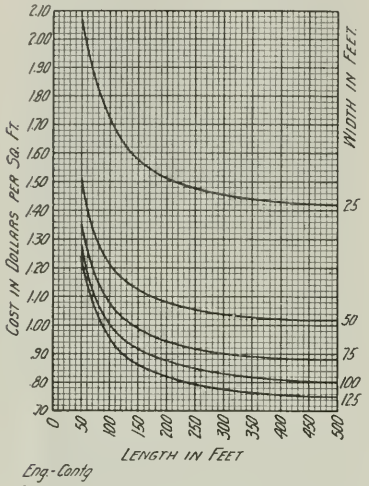

Fig. 5—Cost Diagram for Five-Story Brick Mill Building.

The cost given is for brick manufacturing buildings under average conditions and can be modified if necessary for the following conditions:

(a) If the soil is poor or the conditions of the site are such as to require more than the ordinary amount of foundations, the cost will be increased.

(b) If the end or a side of the building is formed by another building, the cost of one or the other will be reduced slightly.

(c) If the building is to be used for ordinary storage purposes with low stories and no top floors, the cost will be decreased from about 10 per cent for large low buildings, to 25 per cent for small high ones, about 20 per cent usually being a fair allowance.

(d) If the buildings are to be used for manufacturing purposes and are to be substantially built of wood, the cost will be decreased from about 6 per cent for large one-story buildings, to 33 per cent for high small buildings; 15 per cent would usually be a fair allowance.

(e) If the buildings are to be used for storage with low stories and built substantially of wood, the cost will be decreased from 13 per cent for large one-story buildings, to 50 per cent for small high buildings; 30 per cent would usually be a fair allowance.

(f) If the total floor loads are more than 75 lbs. per sq. ft. the cost is increased.

(g) For office buildings, the cost must be increased to cover architectural features on the outside and interior finish.

The cost of very light wooden structures is much less than the above figures would give. Table I shows

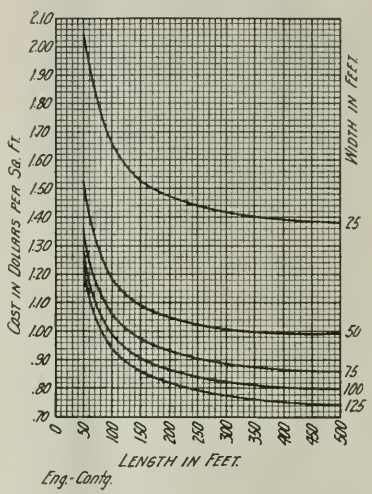

Fig. 6—Cost Diagram for Six-Story Brick Mill Building.

the approximate ratio of the costs of different kinds of buildings to the cost of those shown by the curves.

EVALUATIONS.—The diagrams can be used as a basis of valuation of different buildings.

A building, no matter how built nor how expensive it was to build, cannot be of any more value for the purpose to which it is put than a modern building properly designed for that particular purpose. The cost of such a modern building is then the limit of value of existing buildings. Existing buildings are usually of less value than new modern buildings for the reason that there has been some depreciation due to age and that the buildings are not as well suited to the business as a modern building would be.

Starting with the diagrams as a base, the value can be approximately determined by making the proper deductions.

The diagrams can be used as a basis for insurance valuations after deducting about 5 per cent for large buildings to 15 per cent for small ones, for the cost of

foundations, as it is not customary to include the foundations in the insurable value.

USE OF TABLES.

Table II shows the costs which form the basis of the estimates and these unit prices can be used to compute the cost of any building not covered by the diagrams. The cost of brick walls is based on 22 bricks per cubic foot, costing $18 per thousand laid. Openings are estimated at 40 cts. per sq. ft., including windows, doors and sills.

Ordinary mill floors, including timbers, planking and top floor with Southern pine timber at $40 per M. ft. B. M. and spruce planking at $30 per M., costs about 32 cts. per sq. ft., which has been used as a unit price. Ordinary mill roofs covered with tar and gravel, with lumber at the above prices, cost about 25 cts. per sq. ft. and this has been used in the estimates. Add for stairways, elevator wells, plumbing, partitions and special work.

DEDUCTIONS FROM DIAGRAMS.

(1) An examination of the diagrams shows immediately the decrease in cost as the width is increased. This is due to the fact that the cost of the walls and outside foundations, which is an important item of cost, relative to the total cost, is decreased as the width increases.

For example, supposing a three-story building is desired with 30,000 sq. ft. on each floor:

If the building were 600 ft. x 50 ft., its cost would be about 99 cts. per sq. ft.

If the building were 400 ft. x 75 ft., its cost would be about 87 cts. per sq. ft.

If the building were 300 ft. x 100 ft., its cost would be about 83 cts. per sq. ft.

If the building were 240 ft. x 125 ft., its cost would be about 80 cts. per sq. ft.

(2) The diagrams show that the minimum cost per square foot is reached with a four-story building. A three-story building costs a trifle more than a four-story. A one-story building is the most expensive. This is due to a combination of several features:

(a) The cost of ordinary foundations does not increase in proportion to the number of stories, and therefore their cost is less per square foot as the number of stories is increased, at least up to the limit of the diagram.

(b) The roof is the same for a one-story building as for one of any other number of stories, and therefore its cost relative to the total cost grows less as the number of stories increases.

(c) The cost of columns, including the supporting piers and castings, does not vary much per story as the stories are added.

(d) As the number of stories increases, the cost of the walls, owing to increased thickness, increases in a greater ratio than the number of stories, and this item is the one which in the four-story building offsets the saving in foundations and roof.

TABLE I.—RATIO OF COST OF VARIOUS BUILDINGS TO THAT OF BRICK MILLS, STANDARD CONSTRUCTION.

Superficial	—Frame Mills—						—Brick Store House—						—Frame Store House—					
ft. of floor	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
in 1 sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.	sto.
1,250	.86	.67	...	...	...	...	.80	.73	...	...	...	...	.70	.51	...	...	...	...
2,500	.86	.73	...	...	...	...	.85	.73	...	...	...	...	.75	.58	...	...	...	...
5,000	.89	.78	.75	.73	.70	.67	.83	.80	.78	.76	.76	.75	.74	.60	.56	.53	.51	.48
7,500	.90	.79	.77	.74	.71	.69	.85	.81	.78	.77	.76	.76	.77	.63	.58	.55	.53	.51
10,000	.90	.80	.78	.75	.73	.70	.87	.81	.79	.78	.77	.76	.78	.65	.60	.57	.55	.53
15,000	.91	.82	.79	.77	.75	.72	.89	.83	.81	.79	.78	.78	.81	.67	.64	.61	.59	.56
20,000	.92	.83	.81	.79	.77	.74	.90	.84	.82	.80	.80	.79	.82	.70	.67	.64	.61	.59
25,000	.92	.85	.82	.80	.78	.76	.91	.85	.83	.82	.81	.80	.83	.72	.69	.66	.63	.61
30,000	.93	.86	.84	.81	.80	.77	.91	.86	.84	.82	.81	.81	.84	.73	.70	.67	.65	.62
35,000	.93	.87	.84	.82	.80	.78	.92	.86	.84	.83	.82	.81	.85	.74	.71	.68	.66	.63
40,000	.93	.87	.85	.83	.81	.79	.92	.87	.85	.84	.83	.82	.86	.75	.72	.69	.67	.64
45,000	.94	.87	.85	.83	.82	.79	.92	.87	.85	.84	.83	.82	.86	.76	.72	.70	.67	.65
50,000	.94	.88	.86	.84	.82	.80	.92	.88	.86	.84	.83	.83	.87	.77	.73	.71	.69	.66

TABLE II.—DATA FOR ESTIMATING COST OF BUILDINGS.

	Foundations, including excavations. Cost per lin. ft. For outside walls.	For inside walls.	Brick Walls, Cost per sq. ft. of surface. outside walls.	inside. walls.	Columns including piers and castings. Cost of one.
One story building	$2.00	$1.75	$ .40	$ .40	$15.00
Two story building	2.90	2.25	.44	.40	15.00
Three story building	3.80	2.80	.47	.40	15.00
Four story building	4.70	3.40	.50	.43	15.00
Five story building	5.60	3.90	.53	.45	15.00
Six story building	6.50	4.50	.57	.47	15.00

(3) The saving by the use of frame construction for walls instead of brick is not as great as many persons think. The only saving is in somewhat lighter foundations and in the outside surfaces of the building. The floor, columns, and roof must be the same strength and construction in any case.

Assumed Height of Stories.—From ground to first floor, 3 ft. Buildings 25 ft. wide, stories 13 ft. high. Buildings 50 ft. wide, stories 14 ft. high. Buildings 75 ft. wide, stories 15 ft. high. Buildings 100 ft. wide, stories 16 ft. high. Buildings 125 ft. wide, stories 16 ft. high.

Floors, 32 cts. per sq. ft. of gross floor space not including columns. If columns are included, 38 cts.

Roof, 25 cts. per sq. ft., not including columns. If columns are included, 30 cts. Roof to project 18 ins. all around buildings.

Stairways, including partitions, $100 each flight. Allow two stairways, and one elevator tower for buildings up to 150 ft. long. Allow two stairways and two elevator towers for buildings up to 300 ft. long. In buildings over two stories, allow three stairways and three elevator towers for buildings over 300 ft. long.

In buildings over two stories, plumbing $75 for each fixture including piping and partitions. Allow two fixtures on each floor up to 5,000 sq. ft. of floor space and add one fixture for each additional 5,000 sq. ft. of floor or fraction thereof.

(Note: From the above data the approximate cost of any size and shape of building can be estimated in a few minutes. After the cost of the items given is determined about 10% should be added for incidentals.)

REINFORCED CONCRETE BUILDINGS.

From such estimates and proposals as I have been able to get and from work done it appears that the cost of reinforced concrete buildings designed to carry floor loads of 100 lbs. per sq. ft. or less would cost about 25% more than the slow-burning type of mill construction.

TABLE III.—DATA FOR APPROXIMATING COST OF MILL BUILDINGS OF KNOWN SIZE BUT WITHOUT DEFINITE PLANS MADE.

	Foundations. Incl. excavation. Cost per lin. ft.		Brick Walls. Incl. doors, windows. Cost per sq. ft. surface	
Height of building.	outside walls.	inside walls.	outside walls.	inside walls.
One story.....	$2.00	$1.75	$0.40	$0.40
Two stories...	2.90	2.25	.44	.40
Three " ...	3.80	2.80	.47	.40
Four " ...	4.70	3.40	.50	.43
Five " ...	5.60	3.90	.53	.45
Six " ...	6.50	4.50	.57	.47

ALTERNATE METHOD OF ESTIMATING COST.

FLOORS.—38 cts. per sq. ft. of gross floor space. This price will include column piers, column, castings and wrought iron.

ROOF.—30 cts. per sq. ft., including projection, say 18 ins., including columns, etc.

STAIRWAYS AND ELEVATOR TOWERS—Allow two stairways and one elevator tower in buildings over two stories high up to 150 ft. long. Allow two stairways and two elevator towers up to 300 ft. long. Allow three stairways and three elevator towers over 300 ft. long.

BRICK WALLS.—Enclosing stairs and elevators, estimated as inside walls.

STAIRS—$100 per flight, per story.

PLUMBING.—Allow two fixtures on each floor up to 5,000 sq. ft. of floor space, and add one fixture for each additional 5,000 sq. ft. or fraction thereof. Allow $75 per fixture.

INCIDENTALS.—Add about 10% for incidentals.

ON THE EROSION OF BRONZE PROPELLERS.

The phenomenon of the erosion of propellers made of high tension bronze has of recent years assumed a serious practical importance, and it is satisfactory to find that the solution of the problem of the best method of preventing it has been found by Oswald Silberrad, Ph. D., M. R. S. A., F. C. S., in the Silberrad Research Laboratories. It was observed that the damaged propellers looked to a certain extent as if they had been subjected to galvanic action, the maximum erosion occurring at places not always similarly situated on the propellers. The primary cause appeared to be surface friction, but, on the other hand, propellers exposed to the same tests showed very different results; for instance, in the case of the Cunard Liner *Lusitania* both the backs and faces were equally affected, while the actions on the two surfaces of the propellers of the *Maurctania* were widely different. Moreover, where the surface friction was a maximum it was found that the minimum damage was done on the propellers of certain destroyers. Hence a search was made for secondary causes. The most obvious of these—the presence of dirt in castings and galvanic action—had to be dismissed as impossible, and it was ultimately found that the specific nature was primarily erosion, though secondary causes had important influence. Many tests were carried out in the laboratories with a very large number of alloys of different composition, and the conclusions drawn were as follows: (a) The capacity to withstand this deterioration is not, strictly speaking, dependent on any one physical property, but must rather be regarded as a property peculiar to itself; in short, it would appear to constitute a new physical constant for alloys. (b) In the new alloy, "Parsons' Turbine Alloy," this property has been brought to a remarkable pitch, its resistance to the action under standard conditions being nearly five times as great as that of the old alloy, from which it will be seen that the new alloy is likely to resist all reasonable conditions of wear indefinitely.

COMPLETE EXAMINATION OF WATER FOR BOILER PURPOSES.

Evaporate 1 liter of the water to dryness in a weighed platinum dish, dry at 105° C. and weigh as "total solids." Ignite the residue at a dull red heat over a bunsen burner until all carbonaceous matter is consumed. Cool and weigh. The difference in weight represents "organic and volatile matter."

Add 10 cc. of hydrochloric acid and 35 cc. of water to the contents of the dish, boil, filter, and wash thoroughly. Ignite the residue and weigh as "insoluble mineral matter." After weighing the ignited residue, fuse with eight times as much sodium carbonate. Dissolve the fusion in hot water, acidify with hydrochloric acid, evaporate to complete dryness. Redissolve in a little water and hydrochloric acid, boil, and filter. Wash the residue well with water, ignite, and weigh as silica, SiO_2. Treat the filtrate as described below for the filtrate from the "insoluble mineral matter."

To the filtrate from the "insoluble mineral matter" add ammonia, boil, and filter. Ignite the residue after drying and weigh as ferric oxide and alumina, $Fe_2O_3 + Al_2O_3$. Add to this weight the weight of the ferric oxide and alumina found in the "insoluble mineral matter."

To the filtrate from the iron and alumina, add ammonium oxalate in excess, set aside three hours, filter, and wash. Dry the residue, ignite over a blast-lamp to constant weight, and weigh as calcium oxide, CaO. The weight of any calcium oxide found in the "insoluble mineral matter" must be added to this for the total calcium oxide.

To the filtrate from the calcium oxalate add sodium phosphate in excess, stir well, and add one-third the volume of the solution of strong ammonia. Set aside for some hours. Filter and wash with a mixture of 1,000 cc. of water, 500 cc. of ammonia (sp. gr. 0.96), and 150 grams of ammonium nitrate. Dry the precipitate, ignite, and weigh as magnesium pyrophosphate, $Mg_2P_2O_7$.

Evaporate 250 cc. of the water to be tested to dryness, redissolve in a little dilute hydrochloric acid, filter, wash, and, to the boiling filtrate, add an excess of barium chloride with constant stirring. Allow the solution to stand three or four hours, filter, wash, dry, and ignite. Weigh as barium sulphate, $BaSO_4$.

Concentrate 250 cc. of water in a platinum dish to 50 cc., add a few drops of potassium chromate solution and titrate with standard silver nitrate solution. The slightest excess of silver nitrate causes the solution to turn red.

Calculate the results as follows: Combine the chlorine, first with the magnesium, then if in excess with the calcium. The sulphuric acid is combined with the calcium first, then if in excess with the magnesium. If any calcium or magnesium is left over it is calculated as carbonate. The oxides of iron and aluminum are reported as such.

If the weight of the total solids exceeds by any considerable amount the sum of the chlorides, carbonates and sulphates of calcium and magnesia, the oxides of iron and aluminum, the silica and the organic matter, the water may contain alkalies. In this case:

Evaporate 500 cc. of the water to dryness. Boil the residue with a few cubic centimeters of water, filter, and wash. Treat the solution with an excess of barium hydroxide solution, filter, and wash. Evaporate the filtrate to dryness in a platinum dish and ignite to a dull redness until white fumes cease to come off. Cool, redissolve in water, and add a few drops of ammonia and ammonium carbonate solution. Filter, wash, add a little hydrochloric acid, and again evaporate to dryness. Ignite at dull redness as before, cool and weigh as sodium and potassium chloride. $NaCl + KCl$. Redissolve in water, add platinic chloride in excess, evaporate nearly to dryness, add 20 cc. of 80 per cent alcohol and after all sodium salts are in solution filter on a counterpoised filter. Wash with 80 per cent alcohol. Dry and weigh as potassium platinic chloride, K_2PtCl_6. Multiply this weight by 0.30701 and subtract the result from the weight of the sodium and potassium chloride for the sodium chloride.

In calculating the results, combine the chlorine with the sodium first, if still in excess with the potassium, then with the magnesium and finally with the calcium. The sulphuric acid is combined with the sodium first, if there is not enough chlorine present to satisfy this base, then with the potassium and finally with the calcium and magnesium in the order named. The calcium and magnesium in excess are calculated as carbonates.

DETERMINATION OF THE HARDNESS OF WATER.

Standard "Hard Water."—Dissolve 1.11 grams of fused calcium chloride in water and dilute to 1 liter, or dissolve 1 gram of pure calcium carbonate in dilute hydrochloric acid, evaporate to dryness, redissolve in water and make up to 1 liter. One cc. of either solu-

tion will correspond to 0.051 gram of calcium carbonate.

Standard Soap Solution.—Dissolve 13 grams of sodium oleate, or castile soap, when the former cannot be obtained, in a mixture of 500 cc. of water and 500 cc. of alcohol. Filter if necessary. To standardize, run 12 cc. of the standard "hard water" into a 250 cc. glass stoppered flask or bottle and add 46.3 cc. of water. Now add from a burette 1 cc. at a time of standard soap solution and shake vigorously after each addition. When a point is reached where a persistent lather lasting five minutes is produced, note the burette reading. Dilute the soap solution so that 12 cc. of the standard "hard water" will require 13 cc. of soap solution. (Distilled water requires 1 cc to form a permanent lather.) If it requires *a* cc. of soap solution, to form a permanent lather with 12 cc. of standard "hard water," then to dilute the soap solution, measure the volume left (substitute this volume

$$V\ (13-a)$$

for V in the formula), and add to it ———————— of the

$$a$$

mixture of alcohol and water.

DETERMINATION OF TOTAL HARDNESS.

Run into a 250 cc. glass-stoppered flask or bottle 58.3 cc. of the clear sample of water and add soap solution as described above until a permanent lather forms, which remains five minutes. The number of cubic centimeters of soap solution used minus 1 cc. will give the degrees of hardness of the water in terms of grains of calcium carbonate per U. S. gallon. If it is desired to know the degrees of hardness in terms of grains per imperial gallon, take 70 cc. of water instead of 58.3 cc. Water containing magnesium salts decomposes soap solution slowly, causing an apparent persistent lather which on standing and again shaking up disappears. A little practice will enable the operator to note the right point of hardness in such waters.

DETERMINATION OF PERMANENT HARDNESS.

Boil exactly 250 cc. of the water in a half liter flask for one-half hour. Add boiling distilled water, if necessary, to keep up the volume. Cool, pour into a 250 cc. graduated flask, and dilute to the mark with recently boiled distilled water. Mix well and filter through a dry filter into a dry beaker. Measure 68.3 cc. of this solution into a glass-stoppered flask and determine the permanent hardness as described for total hardness.

DETERMINATION OF TEMPORARY HARDNESS.

The temporary hardness is calculated by deducting the degree of permanent hardness from that of total hardness. The difference is temporary hardness.

RAPID ANALYSIS OF WATER FOR BOILER PURPOSES.

(*Methods used by Pittsburg Testing Laboratory. J. O. Handy, Chief Chemist.*)

Two methods are used. The first is a nearly complete analysis and is made in all cases of a new source of supply. The second is a partial analysis, very quickly and simply carried out, and is used for the purpose of controlling water softening operations.

The first analysis differs from the ordinary method in that the iron, calcium and magnesium compounds in the water are separated into two groups, those soluble in boiling distilled water after evaporation to dryness (sulphates, chlorides, etc.) and those which are insoluble (the carbonates). This method enables us to express out results in a more intelligible form.

The method of water softener control consists in determining only acidity or alkalinity and hardness. Details will be given later as to the method of obtaining and interpreting this data.

METHOD NO. 1—BOILER WATER ANALYSIS.

Bases.—250 cc. of the water are evaporated to dryness in a platinum dish on a steam bath. The first part of the work may be hastened by evaporation over an argand burner at a temperature just below boiling. Care must be taken that no ammonia or acid fumes are present, as they may cause material changes in the composition of the water.

The residue is dried at 110 degrees Centigrade. In many cases the sulphates and chlorides retain some water even at this temperature. The weight of total solids is always higher than the amount found by analysis and calculation.

The dry residue, after weighing, is treated with boiling distilled water (freed from CO_2 by 20 minutes' boiling). The residue is rubbed loose and if large in amount is actually boiled up two or three times with pure distilled water and filtered. The total amount of water used for the separation is not over 150 cc.

The water solution contains all of the alkali salts, together with the sulphates and chlorides of iron, alumina, lime and magnesia. The insoluble residue consists of carbonates of lime and magnesia, with some silica.

The soluble and insoluble portions are analyzed separately. Alkalies are not determined directly except in certain cases, but are calculated and expressed as sodium salts.

The insoluble carbonates are dissolved carefully in hot dilute hydrochloric acid. The iron is precipitated by NH_4OH as usual. If the water is high in magnesia, sufficient NH_4Cl must be present. The iron is determined by dissolving the hydrate in dilute H_2SO_4, reducing with zinc and titrating with $KMnO_4$. Lime is precipitated by ammonium oxalate, filtered, washed, dissolved in hot 2 per cent H_2SO_4 and titrated with $KMnO_4$ (1 cc. = .005 gm Fe = .0025 gm CaO). The filtrate is cooled, 10 per cent of NH_4OH is added and the magnesia precipitated as phosphate in the usual way. If the dilution has not exceeded 250 cc. and the precipitate shows a distinct line of subsidence after ten minutes' stirring and twenty minutes' standing, it may be safely filtered and washed with 10 per cent NH_4OH. The filter papers are allowed to stand at room temperature until nearly dry, to permit the

evaporation of free NH_3. The air must be free from acid or ammonia fumes. Place filter in beaker. Add d. n. H_2SO_4 in excess. Stir until dissolved. Add methyl orange indicator and titrate back with d. n. NaOH (1 cc. = .002 gm. MgO).

The Soluble Part containing sulphates, chlorides, etc., is acidified with HCl, boiled and analyzed for Fe_2O_3, CaO and MgO.

Chlorine is determined by titrating 100 cc. with standard $AgNO_3$, using $KCrO_4$ indicator (1 cc. $AgNO_3$ = gm. Cl).

Sulphuric Anhydride is determined in 250 cc. of water gravimetrically as $BaSo_4$.

Nitric Anhydride is determined by the phenol-sulphuric method. 25 cc. of water are used. If Cl exceeds 5 parts per 100,000 it is removed by Ag_2SO_4 before the water is evaporated for the phenol-sulphuric treatment.

Alkalinity is determined by titrating 100 cc. with d. n. H_2SO_4, using methyl orange indicator.

Acidity is determined by adding to 100 cc. a measured amount of d. n. H_2SO_4, boiling to remove CO_2 and titrating back with d. n. NaOH, using phenolphthalein indicator.

Free CO_2 is determined by Seyler's method.

Silica is determined by evaporating 250 cc. acidified with HCl to dryness and then redissolving in warm dilute Hcl and filtering. Wash, ignite and weigh as SiO_2.

FACTORS FOR CALCULATION OF RESULTS.

$Fe \times 2.09 = FeCo_3$
$CaO \times 1.786 = CaCo_3$
$MgO \times 2.10 = MgCO_3$
$CaO \times 2.43 = CaSO_4$
$MgO \times 3.00 = MgSO_4$
$CaO \times 1.98 = CaCl_2$
$MgO \times 2.36 = MgCl_2$
$CaO \times 2.93 = CaN_2O_6$
$MgO \times 3.68 = MgN_2O_6$
$SO_3 \times 1.7 = CaSO_4$
$SO_3 \times 1.5 = MgSO_4$
$SO_3 \times 1.776 = Na_2SO_4$
$Cl \times 1.564 = CaCl_2$
$Cl \times 1.34 = MgCl_2$
$Cl \times 1.65 = NaCl$
$N_2O_5 \times 1.52 = CaN_2O_6$
$N_2O_5 \times 1.373 = MgN_2O_6$
$N_2O_5 \times 1.574 = NaNO_3$
$CaCl_2 \times .64 = Cl$
$MgCl_2 \times .75 = Cl$

METHOD OF COMBINING BASES AND ACIDS.

Insoluble Fe, CaO and MgO are calculated to carbonates. Alkalinity is expressed as $CaCo_3$. If it exceeds the sum of the $FeCo_3$, $CaCo_3$ and $MgCo_3$ (expressed as $CaCo_3$), calculate the residual alkalinity to Na_2Co_3. If Na_2Co_3 is present no soluble salts of Fe, CaO or MgO can exist. *Any small amounts found* must be calculated as carbonates. Soluble Fe, Al, CaO and MgO are calculated to sulphates if SO_3 suffices. If SO_3 is not sufficient, satisfy these bases in the order mentioned with So_3, N_2O_5 and Cl. Any residual acid radicles are calculated to sodium salts, except in the case of acid waters when free H_2SO_4 is calculated and expressed as such. Silica is expressed as such. Free CO_2 is also stated by itself.

METHOD OF CALCULATING CHEMICALS FOR WATER SOFTENING.

Parts per 100,000.		Pounds per U. S. Gallon.
CaO (insoluble)	× .0925	Commercial lime, 90 per
MgO (insoluble)	× .26	cent CaO, needed.
MgO (soluble)	× .13	"
Free acid (H_2SO_4)	× .053	"
Free Co_2	× .118	"
Fe (as carbonate)	× .093	"
CaO (soluble)	× .166	Soda ash, 95 per cent
MgO (soluble)	× .233	Ha_2CO_3, needed.
Free H_2SO_4	× .095	"

METHODS FOR WATER SOFTENING CONTROL.

(Campbell.)

The tests which are necessary for calculating treatment of hard water are:

1. Hardness.
2. Alkalinity.
3. Acidity (free carbonic acid gas).

The tests required for determining whether the softened water has been properly treated are:

1. Hardness.
2. Alkalinity.
3. Causticity.

The chemical solutions required for these tests are:

1. Sulphuric acid (fiftieth normal).
2. Sodium hydrate (fiftieth normal).
3. Soap solution (fiftieth normal).
4. Methylorange indicator ("red").
5. Phenolphthalein indicator ("clear").
6. Distilled water.

The apparatus required is:

1. Two 50 cc. g. s. burettes and stands.
2. Two porcelain evaporating dishes (6 inch).
3. One wash bottle.
4. Two stirring rods.
5. 100 cc. grad. cylinder.
5. Bottles for soap test, etc.

DETAILS OF TEST.

Bottles.—Use square 8 ounce bottles for hardness and round 4 ounce for alkalinity (or acidity to red indicator) and 8 ounce round ones for acidity and causticity. Always use the same bottles for the same purpose. Always thoroughly rinse out the graduated cylinder or bottle before using it with the same kind of water you are going to test.

Indicators.—The red indicator is for testing for alkalinity and acidity, and the clear indicator for acidity and causticity.

Alkalinity.—Measure 100 cc. of the water and put into the proper bottle and add 3 or 4 drops of the red

indicator; water will then be slightly yellow if it is alkaline. If it is red there is no alkalinity. Fill up the acid burette to the zero mark, then run this into the water a few c. c. at a time at first, and one or two small divisions toward the end, shaking the bottle a little. As soon as the water remains a very light red color after shaking, the test is finished. The number of c. c. solution used is the alkalinity.

Acidity (free carbonic acid).—Measure 200 c. c. of the water to be tested, add to proper bottle and add 5 or 6 drops of the clear indicator. If the water turns at once and remains a pink color, there is no acidity. Fill up the soda burette to the zero mark, then run this into the water one or two c. c. at a time, and shake bottle. As soon as a faint pink color remains after shaking, test is finished. The number of c. c. of solution used is the acidity.

Causticity.—Measure 200 c. c. of treated water and put into proper bottle. Add three or four drops of clear indicator. Water will usually turn pink. Fill acid burette to zero mark, and run in a few c. c. at first, and toward the end ½ c. c. at a time, until the color disappears. The number of c. c. used is the causticity.

Hardness.—Measure 100 c. c. of the water to be tested and put into the proper bottle. Fill the soap burette to the zero mark, then run this into the water to be tested, 1 c. c. at a time, until there is nearly enough in, then only one or two small divisions at a time. Shake bottle vigorously after each addition of soap solution. Note lather carefully; if it disappears, add more soap, until you get the lather to hold for three minutes with the bottle lying on its side. The number of c. c. of solution used is the hardness. If hardness of raw water is greater than 12, then take only 50 c. c. of raw water and add to it 50 c. c. of distilled water. Multiply the number of c. c. of solution used by 2 to get the hardness.

Note.—If the water is acid to red indicator before testing for hardness, add c. c. of soda solution equal to the acidity.

CALCULATIONS OF LIME AND SODA REQUIRED.

Lime.—Alkalinity + acidity (carbonic acid) × .056 lb. equals lime required for 1,000 gallons of water.

Soda Ash.—Hardness — alkalinity × .093 lb. equals soda ash required for 1,000 gallons of water.

The lime and soda are best prepared separately with hot water. The lime must be kept stirred after slaking and while running into the hard water the latter should be stirred also. The lime is usually added first and then the soda solution, but both may be added at the same time. The stirring of the mixture of chemicals and hard water should be kept up for 15 minutes to half an hour, according to the size of the tank and the rapidity of stirring.

Four hours are usually allowed for settling and a floating discharge pipe is used for drawing off the clear water without disturbing the sludge.

As a check on the care of the operative and the efficiency of the process the treated or softened water is tested for alkalinity, hardness and causticity.

Hardness — alkalinity = deficiency of soda (1).

Alkalinity — hardness = excess of soda (1).

Alkalinity — causticity = deficiency of lime (2).

Causticity — alkalinity = excess of lime (2).

From 5 to 6 degrees of hardness are usually left in the treated water.

If the alkalinity exceeds the hardness slightly and is about the same as the causticity, the treatment is right, and good results can be expected in the boiler.

(1) Multiply by .093 lb. to get soda ash per 1,000 gallons.

(2) Multiply by .056 lb. to get lime per 1,000 gallons.

The above formulæ and methods are for waters which are neutral or alkaline in reaction.

For acid waters, the lime required is calculated by deducting the acidity to methylorange from the acidity to phenolphthalein and multiplying the remainder by .056. This gives the pounds of lime required per thousand gallons; the acidity in these cases is obtained by the use of fiftieth normal sodium hydrate solution.

To determine the amount of soda ash required add together the hardness and the acidity to methylorange, and multiply the sum by .093. The result is pounds of soda ash required per thousand gallons. The hardness is determined by the use of fiftieth normal soap solution.

Two hundred cc. of water are used to obtain the acidity to phenolphthalien and 100 for the acidity to methylorange.

One hundred cc. of water are used for the hardness test.

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PRACTICAL APPLICATION OF THE TWITCHELL PROCESS OF FAT DECOMPOSITION AND RECOVERY OF GLYCERIN.*

By W. J. WARNER.

The intention of this article is to state the advantages of the process as applied to refining of glycerin and its advantages and applicability to soap making, as well as a description of the process as "worked" on a commercial basis in a plant handling 50,000 lbs. of fat per day.

The Twitchell process has superseded all others in the candle trade, and is being more extensively used by the soap manufacturers who have recognized the advantages of the process for the recovery of glycerin, in that 95 per cent of all the glycerin in the fat can be obtained as C.P. This will give yields from: good tallow, 9 to 10 per cent absolute glycerin; cocoanut oil, 12 to 13 per cent absolute glycerin; cotton oil, 10 per cent absolute glycerin approx.; grease and poor tallow, 6 to 8 per cent absolute glycerin.

The sweet water to be evaporated contains 15 per cent glycerin instead of from 2 to 4 per cent as in spent lye, and therefore about 25 per cent as much water has to be evaporated to make crude glycerin as with soap lye. As an illustration:

The glycerin refiner is supposed to obtain 9 per cent of absolute glycerin by weight; of the total amount of tallow saponified, actually about 7½ per cent is obtained; as the tallow contained approximately 10 per cent of glycerin the loss is considerable. Instead of having to handle 200,000 lbs. of spent lye containing 3.75 to 4.25 per cent of glycerin, by the Twitchell process of first deglycerizing the fats there would be approximately 60,000 lbs. of sweet water containing 15 per cent of glycerin. Besides having to handle such a large quantity, the spent lye contains salt, alkali, and fats, which are troublesome to remove; the Twitchell sweet water only has to be neutralized with lime before concentrating, consequently there is a reduction in loss of glycerin to almost nothing and a product of crude glycerin containing 90 per cent of absolute glycerin against 80 from soap lye, which means a less expense in the refinery. The Twitchell crude is of better quality, containing but a few tenths of one per cent of ash and C.P. can be made in one distillation, while it often requires three distillations from soap lye crude, so that a still will handle about 30 per cent more per hour of the Twitchell crude and produce less glycerin foots.

The fatty acid obtained can be saponified with soda ash instead of caustic, which means a net saving of 12 cents per hundred pounds of fat saponified, and finally the fatty acid is of much better odor than the original stock.

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In some cases it is of more importance to obtain good color fatty acid than high yield of glycerin, and for working convenience the stock is divided into three classes:

First. No. 1 tallow, mutton tallow, yellow or white cotton oil, cocoanut and palm kernel oil, white grease, olive oil, corn oil, lard, and good stearin. The color and odor are of prime importance.

Second. No. 1 and No. 2 tallow and "off" cotton oil, all the glycerin possible is obtained consistent with good color. Neither the first nor second class of goods goes to the distillation plant.

Third. Very "off" cotton oil, house grease, olive oil foots, and cotton-seed foots go to the distillation plant and are "robbed" of *all* the glycerin, as color, in the Twitchell plant, is of no importance—the distilled product will be white any way.

Outside of the distillation plant the work is carried on exclusively in wooden vats or tanks, each tank numbered for convenience and record, and are designated as decomposing, acid boil, Twitchell, and storage. The decomposing and acid boil tanks are preferably lead lined. The Twitchell tanks are closely covered with snug fitting lids with an "up take" for steam. Experience has taught that certain precautions must be taken to carry out the process successfully and economically and these will be referred to at the proper time.

Assuming that a plant has just been installed, it is of prime importance to understand that in a glycerin refinery and a Twitchell distillation plant twenty-four hours make one day and seven days make a week and there are fifty-two weeks in one year, and there are no Sundays, holidays, or even lunch hours, one shift of employes relieving the other without any interruption of work. The plant is ready, a tank car of cotton-seed foots has been set about 5:30 p. m., each tank car is fitted with a closed steam coil with outside connections, the coil is connected with a steam supply in the "pump house" before which the tank has been placed, and steam turned on to heat and soften the "foots" for pumping in the morning. One of the precautions for successfully working the process is that the fat must be freed from all dirt, lime, bone, tissue, and other impurities, which sounds complicated but is very simply done. The dirt settles and is run off to the sewer. The contents of the car being softened the pump is started. A "pet cock" on the pressure side of the cylinder enables the operator to obtain a "running sample" of the contents of the car. This amounts to about three gallons. This sample is taken to the laboratory, thoroughly mixed and divided into four parts, three parts sealed in pint jars until the car of stock is run through and the fourth part for "immediate analysis" of total fatty acid. Five to 10 grams are weighed into a 300 cc. Erlenmeyer and 50 cc. of a 5 per cent alcoholic soda solution added. Boil to dryness. Add an excess of dilute sulphuric acid and boil until all soap is decomposed. Transfer to a separatory

funnel using some petroleum ether to rinse Erlenmeyer. Draw water and acid off the Erlenmeyer. Pour the solution of fatty acids in petroleum ether onto a filter and filter into a tared dish, add more ether to the water, thoroughly washing Erlenmeyer and separatory funnel, each time pouring the ethereal washings onto filter. Finally wash filter and funnel stem. You now have the total fatty acids in a petroleum ether solution in a tared dish. Dry until the loss is not more than 0.02 grams in 20 min. at 100° C. Before the pump was started six to nine inches of water was turned into the decomposing tank and the steam turned on, an open coil being fitted in the tank. (The water is only used in starting a new plant, thereafter the decomposing tank will contain an indefinite amount of waste acid from the rest of the plant.)

Cotton-seed foots are 50 per cent saponified when received and are "decomposed" into "black oil" by boiling with sulphuric acid. When there is waste acid in the decomposing tanks it is started boiling the same time the car is being emptied so that the saponification is broken up almost as fast as it can be pumped. After boiling an hour it is tested by allowing same to run off a paddle and should show no trace of soap. It is allowed to settle, the water and dirt going to the sewer. (If the first boil has been on waste acid the acid is exhausted when it tastes salty.) After running the settlings into the sewer add about three inches of water and 1 per cent of sulphuric acid and boil until fat is brilliant and clear. Allow to settle. This is waste acid, tastes sour, and does for the first boil on the next car. After settling "skim" the oil from the top with a gravity suction pipe into "black oil storage tank." From storage the clear black oil is run into "acid boil tank" and shows a varying analysis: dry black oil: 50 to 75 per cent fatty acid; 2 to 4 per cent unsaponified; 4 to 2 per cent glycerin; 1 to 2 per cent moisture; ½ to 1½ per cent dirt.

In the acid boil tank 1 per cent of sulphuric acid and just enough water to cover the coil are added. The precaution here is that the waste acid should be 18° B., for cotton-seed foots, to obtain a good product; this waste acid goes to the decomposing tanks. The fat is boiled in the acid boil tank for about two hours, a sample taken for analysis and the stock is ready for the Twitchell tank.

It requires a man of intelligence somewhat above the average unskilled employe to be "Twitchellman." He does the "rough analysis" of the tanks during operation and keeps the records of each tank. Where there are so many tanks it is practically impossible to weigh each charge, so that the tanks are measured and weight of contents per inch calculated. Six inches of water are run in the Twitchell tank and thirty-two inch (30,000 lbs.) black oil, cotton-seed foots being handled, 3 per cent of the weight of the charge of black oil of Twitchell reagent is added, steam turned into the perforated coil, the trap door closed, and the Twitchellman starts his record of that particular tank. First he would ascertain the per cent of fatty acid in the black oil as follows:

The oil would be put in an Erlenmeyer and heated until absolutely dry. Bluish vapors on the surface of the oil indicate a dry condition. Fifty cc. alcohol are put into another Erlenmeyer and warmed. 4.1 cc. of the dry oil are run into the 50 cc. alcohol, alkaline blue used as an indicator, and half normal NaOH run in until neutralized. The number of cc. of NaOH multiplied by 4 gives the per cent of fatty acid. The result is noted in the record. This record must show the number of the tank, amount of charge and class of goods, the per cent of fatty acid the goods contained, amount of Twitchell reagent added, the hour it started boiling, the hour it stopped boiling, the number of hours of the first boil, amount of sweet water run off, and the B° strength and per cent of fatty acid at end of first boil, the hour of starting and ending second boil, number of hours boiling, amount of Twitchell fat run off, and per cent of fatty acid at the finish. The length of time for the first boil is about thirty hours and should show from 87 to 90 per cent fatty acid. After settling the glycerin water is run off into a storage tank, the number of inches and B° taken. The second boil lasts about twenty-four hours; no reagent is added to the second boil. A sample is taken and should show 93 to 95 per cent of fatty acid, it is allowed to settle and is ready for the distillation plant. The Twitchell fatty acid, as the product is now known, shows on analysis: 92 to 95 per cent free fatty acid; 4 to 1 per cent unsaponifiable; 2 to 3 neutral fat; 1 to 1½ per cent dirt.

When the fat has thoroughly settled it is run into an intermediate storage stand and then into the "dry boxes." These dry boxes are of cast iron, built up of sections 2 ft. 6 ins. square with machined edges to make a tight joint, the boxes are 5 ft. wide, 5 ft. deep, and 10 ft. long, and when the fat is dry and at about 275° F. measure 285 lbs. per inch. Each box is fitted with a closed brass coil and connections to the still. It is essential that the fat be absolutely dry when fed into the still. The distillation is carried on by live fire, each still being fitted with a perforated cross on the bottom of the inside of the still through which superheated steam is injected. A slow fire is started under the still and the vacuum pump started. When a vacuum of 28 ins. is obtained, 32 ins. of fat, about 9,100 lbs. are drawn into the still and the temperature gradually raised to 475° F. on the still and 575° F. on the superheater. The superheated steam is then turned into the still through the perforated cross and collection of distilled fatty acid begins. This is continued, slowly feeding fat into the still until 155 ins. has been fed out of the dry boxes, approximately 34,000 lbs. The stillman keeps close watch of measurement of the distilled product because he only obtains 82 per cent of what he feeds in, the residue gradually becoming bulky. When the "charge" has been fed in, the tem-

perature has been raised gradually to 525° F. on the still and 650° F. on the superheater and the time has been about three days of twenty-four hours. The distillation is continued until fat begins to color, when the fires are drawn, superheater shut off, and temperature on the still allowed to drop below 500° F. Then the tar is pumped into a tar still. This tar seems to have a "flashing point" of 500° F. in contact with cold air. The safe point to pump is 475° F.; it has been pumped at 495° F. but *only* once, and when the wreck was cleaned up the yield of tar was not quite as large as it should have been. The tar still is the same as the fat still, except it is not operated under a vacuum. The remaining grease is blown out of the tar with superheated steam, the tar allowed to cool, run off and barreled. In the meantime, the fatty acid still is again started. The process described applies only to the lower grade of fat or Class No. 3. Classes No. 1 and No. 2 do not go to the distillation plant. The Twitchell tank for handling these goods is the same as for Class No. 3 with the addition of being fitted with a steam jet immediately under the cover and above the surface of the fat. The method followed for, say, prime tallow applies to all other fats in Classes No. 1 and No. 2.

The tallow is "steamed out" of barrels into the acid boil tank and 5 lbs. of sulphuric acid to each barrel of tallow added and boiled for two hours, then allowed to settle overnight. Run water off and drop to Twitchell tank. Assuming the Twitchell tank is clean, add about ⅓ as much water as there is tallow and ¼ of 1 per cent of the weight of tallow of reagent and boil with open coil until test shows 90 per cent free fatty acid, shut off open coil and turn steam through jet and keep it going all during the settling process. Air coming in contact with the fat at this stage would discolor it. When the sweet water has settled, run off, put in more fresh water and give second boil until test shows 96 per cent free fatty acid, shut off steam, turn on jet, and add barium carbonate mixed with a little water in proportion of ¼ lb. barium to every 500 lbs. stock. In a few moments take a sample from cock in side of tank and test if water is neutral to methyl orange. If it is, steam may be turned off jet and water allowed to settle. The fatty acids are now perfectly stable and may be stored in wood until wanted.

The glycerin waters are treated with milk of lime until distinctly alkaline, the liquor being kept agitated to prevent settling of the calcium sulphate. The treated glycerin water, or sweet water as it is designated, is pumped through a filter press into a storage tank from which it is drawn for evaporating into crude. This can be done in an open tank with closed steam coil or in a vacuum apparatus either single, double or triple effect, to 34° B, which for Twitchell crude is 90 per cent absolute glycerin and 80 per cent absolute glycerin for soap lye crude. All crudes are analyzed before refining, the acetin method being generally used by the large refiners, experience showing the results obtained are more nearly accurate than by the bichromate method.

To conduct this test take: 1½ gm. crude glycerin; 10 gm. anhydrous soda acetate; 8 cc. acetic anhydride. Boil under reflex condenser for 1½ hours, cool a little and dissolve tri-acetin formed in 50 cc. warm water. Do this while still under reflex, cool and filter, washing filter well, add phenolphthalein to filtrate and neutralize excess of acetic acid with 2 per cent solution NaOH, taking *great care* not to run over end point or let solution become alkaline locally while adding the NaOH. Then add an excess of 10 per cent solution NaOH and boil 20 minutes. Titrate excess, also run blank on the 10 per cent NaOH. Titration of blank minus titration of excess divided by weight of sample, multiplied by 1.533, equals per cent of glycerin.

The following yield and capacity tests (the cost test for obvious reasons being omitted) will indicate how thoroughly a plant and laboratory can check results.

Cotton foots, 703,580 lbs.; laboratory test, 58.32 per cent fatty acid. Reagent, 17,812 lbs.; laboratory test, 70 per cent fatty acid. This shows for the foots, 410,333 lbs. fatty acid, and for the reagent, 13,359 lbs. fatty acid, a total of 423,692 lbs. fatty acid to be accounted for.

The product, based on a total distillation:

	Lbs.	Per cent.
Distilled fatty acid	355,725	83.87
Tar residue	65,419	15.44
Total recovered product	421,144	
Showing a loss of	2,548	.59
	423,692	100.00

The yield based on analysis of black oil:

	Lbs.	Per cent.
Distilled fatty acid	342,505	82.31
Glycerin	5,775	1.40
Tar	65,419	15.72
	413,699	
Laboratory test	410,333	58.32
Glycerin	5,775	.82
	416,108	

Equals a loss of 2,409 lbs., or .60 per cent.

The yield based on total product handled:

	Lbs.	Per cent.
Distilled fatty acid	355,725	49.31
Glycerin	5,775	.82
Tar	65,419	9.70
Total recovered	59.20 per cent of foots	
Laboratory test	59.55 per cent	
Loss	.35 per cent	

The manufacturers of lard compounds refine their own cotton oil and sometimes decompose the resulting foots into black oil for economy in storage. This

black oil is marketed for Twitchell, a test of a car showed: Black oil, 45,460 lbs.; reagent, 2,025 lbs.

Product:

	Lbs.	Per cent.
Distilled fatty acid	30,618	67.35
Glycerin	3,173	6.98
Tar	11,028	24.25
Loss	641	1.42
	45,460	100.00

The yield of tar on this test was excessive and indicated that some one was not familiar with the process of decomposing foots to the advantage of the distillation plant. If the process is properly handled, the quality of the stock considered, the yield of tar rarely exceeds 12 per cent of the amount of Twitchell grease handled.

Test on house grease.

	Lbs.
Amount of grease 30,750 lbs., less moisture 6 per cent	30,566
Reagent	675

Analysis of Grease.

	Per cent.
Titre	39.8
Saponified value	O K.
Fatty acid	26.8
Moisture	.6
Unsaponifiable	.96

Analysis Twitchell Fat.

Fatty acid	92.39
Unsaponifiable	1.96
Moisture	Trace

Analysis Oil Blown Out of Tar.

Fatty acid	3.86
Unsaponifiable	96.14

Analysis Distilled Fat.

Titre	40.5
Moisture	.8
Unsaponifiable	.65
Saponifiable	98.55

Yield:	Lbs.	Per cent.
Distilled fat	24,182	77.40
Glycerin	1,360	4.40
Tar	2,200	7.00
Unsaponifiable	1,172	3.80
Loss	2,327	7.40
		100.00

The loss on handling house grease was excessively high and was due to the large percentage of volatile or higher fatty acids in the grease, which passed through the entire system of condensors, even through the duplex wet vacuum pump, appearing in billows of grease, perfectly white on the surface of the hot well. They clogged the valve chambers of the pump so that the plant had to shut down, the grease be cleaned out and new valves put in. To have collected and identified those fatty acids would have been an interesting experience, but being a commercial plant one car of such stock gave all the experience cared for.

THE HOEPFNER ZINC PROCESS.

The Hoepfner zinc process adopted by Brunner, Mond & Co. consists in roasting the ore and leaching the metal out as a sulphite with SO_2 solution. This is oxidized by aeration, and the zinc sulphate converted into chloride by salt (NaCl). The electrolyte is a solution of zinc and other chlorides; the cells are divided into anode and cathode compartments by diaphragms. The cathodes are rotating discs of zinc, only partly immersed in the electrolyte; the anodes are carbon or lead. Mond substituted revolving rolls for the discs. The zinc sulphate solution may be chloridized by mixing with the waste calcium chloride, liquors from the ammonia-soda process. Calcium carbonate ('pearl-hardening') in a form desired by paper makers is thrown down as a by-product, and chlorine gas is liberated at the anodes, available for making bleaching powder. The zinc obtained by this process is particularly pure, and is valuable for making brass for cartridge cases.

According to British Consular reports the manufacturing of air nitrates for fertilizer is rapidly increasing in Norway. About $6,000,000 has been expended on the works at Notodden and Svaelgfos and the power stations under construction at Rjukan and Vamma. When all the works are completed, at the end of 1910, $14,600,000 will have been spent. A great point in connection with the development of this industry, is that the opportunity has now arisen of opening up several industries in connection with the manufacture of nitrates, such as nitric acid, nitrate of ammonia, nitrate of potash, also sodium nitrate, which last is already being manufactured. The Nobel syndicate, in conjunction with the Birkeland and Eyde Co., is now concentrating the weak acids, with the assistance of the gas furnaces, to an acid of such percentage as to become an article of transport, and further opportunities have thus been opened for export trade, especially from works with water power that are situated near the seaboard. It is of interest to note that no coal is used in the production of saltpeter or other products here referred to. It is stated authoritatively that there is no probability for many years to come that the sale of saltpeter produced by the method practiced at the Notodden and Rjukanfos works will be disturbed by competition with Chilean saltpeter on the question of price. When the Rjukan Falls works are fully completed they and the Notodden works combined will represent 240,000 horsepower, with a production of saltpeter representing an export value of $6,164,000. The value of the output of nitrates in Norway in 1908 was about $536,000, and the total expenses amounted to $402,000.

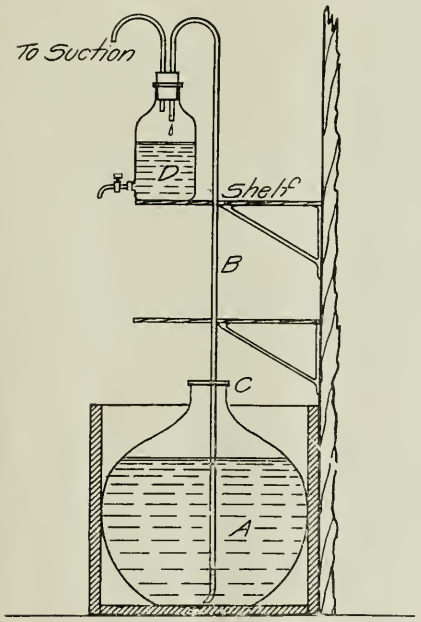
THE LABORATORY

A CONVENIENT METHOD FOR HANDLING ACIDS.

By EDWARD ROE.

The following device is simple and inexpensive, and its advantages are many. Nothing but glass comes into contact with the acid, no fumes escape into the air, the carboy is not subjected to pressure, nor is it necessary to move it, thus obviating all danger of splashing, etc.

The figure is self-explanatory. *A* is the carboy, *B* a glass tube ¼ inch diameter, bent at the lower end so that the bottom of the acid may be reached; *C* is a loose cover of sheet packing, to keep dust out of the



carboy; *D* is a 2-liter bottle, closed with a 2-hole stopper. The tube *B* passes through one hole, and a short bent tube through the other, to which is connected by means of a rubber tube a suction or filter pump (Chapman's or Richards').

On starting the pump, a partial vacuum is created in the bottle and the acid flows into it. To stop the flow it is only necessary to disconnect from the pump. By using an aspirator bottle with a glass stopcock at the bottom tabulature, the apparatus may be made permanent and need not be disturbed until the carboy is empty.

DETERMINATION OF LEAD IN LEAD ORES.

Gravimetric Method.[1]

Weigh 1 gram of the ore if rich, more if poor, into a platinum dish, cover with a watch-glass and add 40 or 50 cc. of a mixture of one part sulphuric acid (sp. gr. 1.84) and three parts nitric acid (sp. gr. 1.42). Heat the covered dish on a hot plate until the action of the acids on the ore has apparently ceased. Then remove the watch-glass and rinse into the dish. Add 10 to 15 cc. of hydrofluoric acid to the solution in the dish and evaporate until dense white fumes of sulphuric acid begin to come off. It is better to conduct the evaporation under a hood for obvious reasons. Remove the dish from the source of heat and cool. Dilute to about 100 cc. with water, digest until all soluble salts are in solution and filter, washing first with a 2 per cent solution of sulphuric acid, and then with alcohol. Dry, detach the precipitate from the filter-paper, burn the latter in a small porcelain crucible. Moisten the ash with a few drops of nitric acid and heat. Add a drop of sulphuric acid, drive off the acid on the hot plate and ignite gently. Then add the precipitate and ignite. Weigh as lead sulphate and calculate per cent of lead in the ore.

Volumetric (Molybdate Method.)[2]

Ammonium Molybdate.—Dissolve 8.64 grams of ammonium molybdate in water and dilute to exactly 1,000 cc. Standardize as directed below. One cc. of this solution should be equivalent to —gram of lead.

Ammonium Acetate.—Dissolve 200 grams of ammonium acetate in 1,000 cc. of water.

Tannic Acid.—Dissolve 0.33 gram of tannic acid in 100 cc. of water.

Standardization.—Dissolve two pieces of pure lead foil weighing about 0.3 and 0.5 grams respectively in 10 to 15 cc. of 1 to 1 nitric acid. When the lead is dissolved, add 20 cc. of 1 to 1 sulphuric acid. Stir thoroughly and allow to settle. Decant on the filter paper and wash by decantation three or four times with water containing 2 per cent sulphuric acid, always decanting as closely as possible. Wash once with a little cold water, keeping as much of the precipitate in the beaker as possible. Dissolve the lead sulphate that is on the filter paper by pouring over it 50 cc. of ammonium acetate solution hot. Pass the solution through the filter a second or third time if necessary, then wash the paper with hot water. Pour the hot ammonium acetate solution over the main bulk of the precipitate. Heat until this is dissolved,

[1]Meade, *J. Am. Chem. Soc.*, 19, 374.
[2]Provisional Method of the Western Society of Chemists and Metallurgists.

dilute to 200 cc. Make barely acid with acetic acid and titrate.

Titration.—The ammonium molybdate is run with constant stirring, testing from time to time by placing a drop of the solution upon a drop of the tannic acid solution on a spot plate. When this gives a yellow color the titration is finished.

Determination.—Dissolve 0.5 or 1.0 gram of ore in 10 cc. of nitric acid and 10 cc. of strong sulphuric acid. Evaporate to white fumes, cool, dilute to 50 cc. and boil. Decant on the filter paper and wash by decantation 3 or 4 times with hot water containing 2 per cent sulphuric acid, then once with a little cold water. Now, with the acid of a wash-bottle transfer the sulphates from the filter back to the beaker, add 50 cc. of ammonium acetate and boil thoroughly. (This procedure is necessary on account of the fact that lead sulphate is not readily soluble in ammonium acetate when other sulphates such as barium and calcium are present.) Filter again through the original filter, wash with hot water, make the filtrate slightly acid with acetic acid and titrate.

Volumetric (Chromate-Oxalate Method.)[3]

Sodium Acetate Solution.—Dissolve 200 grams of commercial sodium acetate in 1,000 cc. of water and add 40 cc. of 80 per cent glacial acetic acid.

Potassium Bichromate Solution.—Dissolve 50 grams of commercial potassium bichromate in 1,000 cc. of water.

Oxalic Acid Solution.—Dissolve 333 grams of oxalic acid in 1,000 cc. of water.

Potassium Permanganate.—Dissolve 1.5185 grams of pure potassium permanganate in water and dilute to exactly one liter. To standardize weigh out 0.0599 gram of pure crystallized oxalic acid (= 0.1 gram lead), dissolve in 125 cc. of water, add 5 cc. of strong sulphuric acid. If not already so, heat to 60° C. and titrate against the permanganate.

Lead value = oxalic acid value × 1.669.

Determination.—Weigh 0.5 grams of the ore into a porcelain dish, cover with a watch glass and add gr. 1.84) and three parts nitric acid (sp. gr. 1.42). Heat the covered dish until action ceases, uncover and rinse the watch glass off into the dish. Evaporate contents of the dish until dense white fumes begin to come off. Cool, dilute to 50 cc., filter on a 9 cm. filter and wash with 2 per cent sulphuric acid. Dissolve the lead sulphate on the filter with a jet of hot sodium acetate solution contained in a wash bottle, receiving the filtrate in the original dish. Agitate the contents of the dish and heat if necessary to redissolve any separate precipitate. Add 10 cc. of a 5-per cent solution of commercial potassium dichromate, and boil gently for a few minutes to render the precipitate basic, when it is easily filtered. The change is shown by its becoming reddish yellow in color. Filter while hot, wash out the dish with hot water and wash the precipitate once. Wash off the lead chromate into a flask with a jet of hot oxalic-acid solution, using from 25 to 40 cc. Heat nearly to boiling in a wash bottle, add grain alcohol to the mixture in the flask and boil until the chromic acid is reduced and the lead is converted to oxalate. Remove from the heat, add 30 cc. of cold water and cool thoroughly in cold water. When cold filter and wash the precipitate thoroughly. Place 5 cc. of strong sulphuric acid in the flask and dilute with a little cold water, and add about 125 cc. hot water. Add the filter and precipitate and titrate with standard potassium permanganate solution. The solution used for iron determination will serve.

[3] A. H. Low, J. Am. Chem. Soc., xxx, 4, 587.

STANDARD HYDROCHLORIC ACID SOLUTIONS.

Standard hydrochloric acid solutions, according to Hulett and Bonner (Jour. Am. Chem. Soc. XXXI, p. 390), having a "constant boiling" point is capable of use as a basis for volumetric work. Starting with an acid of almost any strength, and distilling, a point is soon reached where the degree of acidity in the retort and that condensed holds the same strength of acid. At 760 mm. pressure the density (at 25 degrees C.) is 1.0962 and the strength 20.242 per cent HCl, or 180.17 gm. of distillate will contain 36.47 gm. HCl. The boiling point is 108.54 degrees C. The variations due to changes of barometric pressure likely to occur are not great. The table given is:

Barometric pressure.	HCl, Per cent.	Gm. for 1 mol. HCl.
770	20.218	180.390
760	20.242	180.170
750	20.266	179.960
740	20.290	179.745
730	20.314	179.530

Starting with an acid of specific gravity 1.10 after distilling over three-fourths, the succeeding distillate will not vary over one part in 1,000 from the above figures.

According to a recent consular report the production of copper in Russia in 1908 was 16,591 tons; in 1906 the production was 10,306 tons, and in 1907 14,554 tons. Of the metal produced in 1908 8,420 tons came from the Ural, 4,780 tons from the Caucasus, 2,416 tons from Siberia and the Kirgling steps and all other districts yielded 966 tons. The consumption of copper in Russia in 1908 was 16,478 tons of domestic production and 4,855 tons of imported metal.

Prof. Winslow of Boston reports as a result of his examination of 200 samples of air in plumbing installations, that if a person applied his mouth to the upper end of a house drainage pipe and breathed the air for 24 hours, he would inhale fewer intestinal bacteria than he would take into his stomach in drinking a quart of New York water. In other words, the danger of contracting specific diseases from sewer air is slight.

METHODS FOR TAKING THE SPECIFIC GRAVITIES OF SOLIDS AND LIQUIDS.

SOLIDS.

When the substance whose specific gravity is desired is in the form of a fragment, weigh it accurately in the air; then weigh while suspended from the arm of the balance by a fine silk fiber, and entirely immersed in a beaker of freshly boiled, distilled water. The manner of suspending the solid and of supporting the beaker is shown in Fig. 1.

If W = weight of the substance in air, W = weight of the substance in water, then the specific gravity of the solid $= \frac{W}{W - W}$.

In taking the specific gravity of ores, etc., greater accuracy can be obtained by having the sample in the form of a fine powder. The pycnometer (see under liquids) is first filled with recently boiled distilled water, the temperature brought to 15.5° C. and the whole weighed. The pycnometer is next dried and weighed, a few grams of the ore introduced and the weight again taken. The difference between the last two weights is the weight of the ore. Now fill the pycnometer nearly full of water and boil for a few minutes, cool to 15.5° C., fill to the mark with water also at 15.5° C. and weigh.

If W = weight of the ore,

p = weight of the pycnometer filled with water.

c = combined weight of the ore, pycnometer and water, then the specific gravity of the ore $= \frac{W}{p + W - c}$.

When the substance is soluble in water, use, in place of this some liquid in which it is insoluble. To calculate the specific gravity of the solid multiply the result obtained by whichever of the above formulas the case may require by the density of the liquid used, $\frac{W}{W - W}$ becomes $\frac{W}{W - W} \times D$ and $\frac{W}{P + W - C}$ becomes $\frac{W}{P + W - C} \times D$, where D is the specific gravity of the liquid substituted.

When the substance is lighter than water attach a sinker whose weight in water is known after weighing the substance in air and take the weight of both in water.

If W = weight of the solid in air,

S = weight of the sinker in water,

C = combined weight of the solid and sinker in water, then specific gravity of the solid $= \frac{W}{W - C + S}$.

In case the solid is a powder substitute for water some liquid whose specific gravity is less than that of the substance and calculate its specific gravity as directed for substances soluble in water.

Specific gravity $= \frac{W}{P + W - C} \times D$, where D = specific gravity of the liquid substituted.

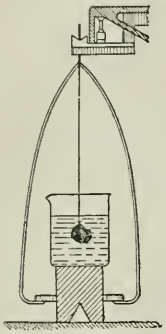


Fig. 1.

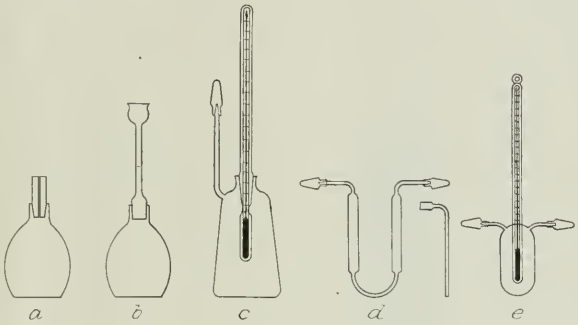


Fig. 2.

LIQUIDS.

For taking the specific gravity of liquids a small bottle called a pycnometer is used. Fig. 2a and 2b show the more common form. In all forms, the idea is to enable the operator to precisely fill the bottle with water. In Fig. 2a this is brought about by drilling a small hole through the stopper. Another form (Fig. 2c) is provided with a thermometer passing through its stopper while the constancy of volume is secured by a side tubule which is closed by a cap. The objection to the first form is the probability of an overflow in weighing caused by expansion of the water on moving to the warmer atmosphere of the balance case.

The pycnometer is first weighed dry, then filled with recently boiled distilled water and immersed in a beaker of water a little above or below the standard temperature according to the temperature of the distilled water. As soon as the water in the pycnometer shows the proper temperature, insert the stopper and quickly dry the bottle with a clean, dry cloth. The

top of the stopper should be wiped with a dry hand since a cloth or other porous body would absorb some of the liquid contained in the capillary bore of the bottle. The pycnometer and its contents are then weighed as rapidly as possible. A precisely similar series of operations is next carried out with the liquid whose specific gravity is desired.

If P = weight of the pycnometer,

W = weight of the pycnometer filled with water,

L = weight of the pycnometer filled with the liquid, then the specific gravity of the liquid = $\frac{L-P}{W-P}$.

The Sprengel tube may be used to replace the pycnometer and is easily made by drawing out both

Fig. 3.

ends of a piece of thin-walled tubing into capillary tubes and bending in the middle to the form of a U. The two capillary tubes are bent at right angles (Fig. 2d). The size of the opening of one fine tube is reduced by drawing it out in the flame and a light mark made on the other capillary tube with a file. The tube is cleansed, dried and weighed. It is now filled with water by immersing the unmarked end in water and applying suction at the other end. The liquid should be drawn up beyond the marked end. The tube and its contents are then brought to the proper temperature by handing in a beaker of water of the requisite temperature. The water should still extend beyond the marked place on the capillary tube. A piece of filter-paper is gently pressed against the pointed end. The water will be sucked out and as soon as the water reaches the mark the filter-paper is withdrawn, the tube removed from the water, dried with a cloth and weighed. The tube is then emptied, dried, filled with the liquid whose specific gravity is required, in the manner described above, and finally weighed. The calculation is made in the same way as when the pycnometer is used.

To dry pycnometers rapidly, rinse out first with distilled water, then with alcohol and finally with ether. A few minutes on the radiator or hot plate will then suffice to dry the bottle.

Hydrometers are used for rapidly determining the specific gravity of liquids. They are usually in the form of a glass or metal float (Fig. 3) weighted below so as to cause them to assume a vertical position when placed in a liquid. The stem is so graduated that the number which is level with the surface of the liquid when the thermometer is floated upon it shows the specific gravity of the liquid. The temperature of the liquid must be the same as that for which the hydrometer is graduated, usually 15.5° C. In taking

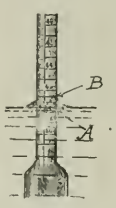


Fig. 4.

the reading of the hydrometer the point A and not the point B is the one to be noted as the specific gravity of the liquid. (See Fig. 4.)

Specific gravity determinations of liquids may also be rapidly made by means of the Westphal balance, an improved form of which was described in THE CHEMICAL ENGINEER for June, 1909, on page 191.

In recording specific gravities it is usual to express temperatures as a fraction in which the numerator expresses the temperature at which the volume of liquid is taken, and the denominator, that at which the volume of water is taken. For example, the specific gravity of a sample of petroleum ether is 0.6448 at 15°/4° C. This means that the ratio of a volume of petroleum ether at 15° C. and an equal volume of water at 4° C. is as 0.6448 is to 1.0. If it had been 0.6448 at 15°/15° C. then the volume of water and petroleum ether were compared at the same temperature.

Consul B. S. Rairden, of Batavia, reports that at the first public sale of billiton tin (by tenders) for the year 1910, held at that city January 5, there was put up for sale 5,500 slabs of tin, each slab weighing 74.8 pounds, which found purchasers at $0.3116 per pound.

METALLURGY.

METAL LOSSES IN COPPER SLAGS.*

By LEWIS T. WRIGHT.

It is commonly believed by metallurgists that in copper smelting, the copper in the slags, which is irreducible by continued smelting, is retained in the form of "prills" of matte.

I have frequently held well settled slag in a molten condition for a long period without being able thereby to reduce the copper content. The slag acted as though it contained a minimum of dissolved or combined copper that could not be settled out by gravity. I have used reagents, but without satisfying myself in what form this copper existed. The same slags, by fine grinding and elutriation, could not be separated into portions containing more or less copper than the average content.

By treating copper slags in an electric furnace an impure button of copper was produced, but the high temperature and the strong reducing action of the furnace were influences that suggest an explanation of a result not obtainable with ordinary smelting temperatures.

If all the copper in the slag were in the form of copper matte, and not existing as a dissolved compound with some of the elements of the slag, then the other metals in the matte, such as gold and silver, should occur in the slag in the same ratio to the copper as to the copper in the accompanying matte.

This reasoning led me to study the ratio of metals in the products of smelting, and, apart from the issues here discussed, the research has proved both interesting and illuminative.

On the assumption of a similar ratio of metals in matte and slag, if the percentage of copper in the slag accompanying a matte containing 50 ounces of silver and 1 ounce of gold per ton of copper was 0.3 per cent, or 96 ounces per ton of slag, there should be found 0.15 ounce of silver and 0.003 ounce of gold per ton of slag; but, in my experience, there is less silver and much less gold in the slag than is required by the assumed law of similar metal ratios.

In order to investigate this point, many accurate assays of matte and slag, covering long periods of time, were grouped into series so as to obtain an average effect of contemporaneity of occurrence of both products, viz., matte and slag, and it was found that the greater the concentration of gold and silver in the copper matte, the less, relatively, is the copper-gold-silver ratio in the slag.

Some of the results obtained, and which are now given in table above, illustrate the general nature of the ratios thus discovered:

TROY OUNCES OF GOLD AND SILVER PER TON OF COPPER.

—Matte—		—Slag—		—Ratios—	
Gold Ounces	Silver Ounces	Gold Ounces	Silver Ounces	Gold: in slag in matte	Silver: in slag in matte
27.9	62.8	8.65	48.9	0.31	0.78
3.5	33.2	2.3	30.9	0.66	0.93
2.5	166.4	1.62	127.8	0.65	0.76
3.04	152.0	2.10	116.0	0.69	0.76

It should be noted that in the table the precious metals are not stated in the ordinary manner in ounces per ton of matte and slag respectively, but in ounces per ton of copper. Thus a 50 per cent matte containing 13.95 ounces of gold per ton of matte is shown in the table as containing 27.9 ounces of gold. In the same manner, the slag stated in the table as containing 8.65 ounces of gold would, if it contained 0.3 per cent of copper, in the ordinary manner be stated as containing 0.02595 ounces of gold per ton of slag.

If all the copper in the slag existed as matte entrained in the slag, the metal ratio should be the same as in the matte; but this is not so in practice.

David Browne, of Sudbury, Ontario, informs me that the nickel-copper ratio of matter is not the same as that of the accompanying slag.

Although there is not enough data as to the form, or forms, in which the irreducible copper exists in the slag to justify more than a suspension of judgment on this point, still the relations noted indicate that the metals are dissolved in the molten slag.

The reversible chemical reaction, $C_2S = CuS + Cu$, explains the presence of free copper in solid copper mattes, which is more marked in high-grade than in low-grade mattes. If free copper, also, exists in the molten matte and in increased quantity with the higher grade, the general observation that the copper carried away in well settled slag increased with the grade of the accompanying matte is more suggestive of the influence of some physico-chemical property than of the fortuities of mechanical separation. Between the limits of 15 and 45 per cent copper matte the accompanying slags increase by an average of 0.005 per cent of copper per 1 per cent of increase of copper in the matte.

This increase, given in Fig 1 as a curve, shows a well marked flattening between 20 and 37 per cent copper matte, and depression at 25 and 37 per cent.

The distribution of a soluble body in two solvents is independent both of the relative amounts of the two solvents present and of the absolute concentration. The substance is distributed so that the ratio of its con-

*Read before the New Haven Meeting of the Amer. Inst. Min. Eng.

centration in each solvent is constant. If this so-called "law of distribution" were strictly applicable to copper mattes and accompanying slags, and there were no interfering or modifying influences, then the ratios given in table would be nearer to 1 than they are.

Other things being equal, a difference of 1 per cent of SiO_2 in the slag makes a regular difference of about 0.01 per cent in its copper content. The regularity of this occurrence is more suggestive of solution than of difference due to more or less perfect settling.

If slag formed in making a matte having a certain metal ratio be kept in molten contact with matte possessing a different metal ratio, the slag will acquire a new metal ratio due to that of the latter matte. The matte and slag appear to act as solvents and divide the metals accordingly.

If slag formed in making matte carrying a large quantity of precious metals be kept in molten contact with matte containing a small quantity of precious metals, the silver and gold will go out of the slag into the matte, although the percentage of copper in the

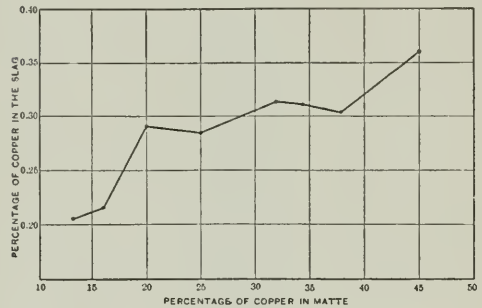


Fig. 1.

slag, other things being equal, will remain constant. In this way the precious metals may be almost entirely removed from copper slags.

I applied this knowledge of metal ratios to great advantage in smelting copper ores.

In a series of three reverbatory furnaces the middle one was built with a hearth lower than the others. All the slag from the outside furnaces is tapped through the middle furnace. The charge smelted in the outside furnaces yields a matte having high precious metal values, while that in the middle and lower furnace yields a matte low in precious metal values. In this way all the slag produced in either the outer or the inner furnaces can be discharged low in copper, gold, and silver.

The middle, or "cleaning," furnace smelted 6 per cent more ore charge than the two outer furnaces and consumed 17 per cent less fuel, giving a total saving of 21.7 per cent of fuel. The slag from the outer furnaces was not considered a part of the "ore-charge."

By using this method of smelting copper ores the precious metals are recovered with an increased furnace output and a large economy in fuel consumption.

THE EFFICIENCIES OF CRUSHERS.*

By R. W. CHAPMAN.

When making comparisons of the efficiencies of different crushing machines it is desirable to be able to estimate the work actually done in crushing the ore from a given size of feed to a given size of product, the screen analysis of both feed and product being determined. The method proposed for such calculations is based upon the principle that if a quantity Q of material that will just pass through a screen of m meshes to the linear inch be crushed until it will pass through a screen of n meshes to the inch, then the work done in crushing is proportional to $Q(n - m)$. This statement is based on experiments and the following reasons and assumptions:

Suppose a quantity Q of material is made up of particles of an average diameter x, then number of particles is proportional to quantity divided by the volume of each particle; that is, to $\frac{Q}{x^3}$. Now, let the particles be crushed to some smaller diameter y. If one of the original particles is a cube, whose side is x, and this

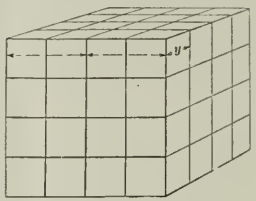


Fig. 1.

is divided up into cubes each of side y, the division may be effected by shearing along three sets of parallel planes at right angles as shown in Fig. 1. The number of such shearing planes parallel to one side is $\frac{x}{y} - 1$, and these are each of area x^2. In order to divide up the original cube, then, along one set of these parallel planes the work required to be done is proportional to $\left(\frac{x}{y} - 1\right)x^2$, and since the shearing has to be effected along three such sets of planes, the total work done is measured by $3\left(\frac{x}{y} - 1\right)x^2$. But there are $\frac{Q}{x^3}$ particles, and therefore the total work done in reducing a quantity Q from average diameter x to diameter y is measured by $\frac{Q}{x^3} \times 3\left(\frac{x}{y} - 1\right)x^2$, or, leaving out the constant, $Q\left(\frac{1}{y} - \frac{1}{x}\right)$. According to this, if we now further crush down to diameter z the additional work done is $Q\left(\frac{1}{z} - \frac{1}{y}\right)$, and the total work done in crushing from diameter x to diam-

*From a paper read before the Australasian Institute of Mining Engineers.

eter $z = Q\left(\frac{1}{y} - \frac{1}{x}\right) + Q\left(\frac{1}{z} - \frac{1}{y}\right)$, which $= Q\left(\frac{1}{z} - \frac{1}{x}\right)$, the same as if the crushing were all done in one operation.

To make the computation, then, it is necessary to determine the reciprocal of the diameter of the particle. But this is very nearly double the number of meshes per linear inch of the screen through which the particle will just pass, as is seen from Table 1 for the I. M. M. standard laboratory screens.

It consequently follows that the crushing of a quantity Q of ore, consisting of particles of uniform size that will just pass through a screen of m meshes per linear inch down to another uniform size, such that they will just pass through a screen of n meshes per linear inch, requires an amount of work proportional to $Q\ (n - m)$.

If, then, we have material fed into a machine consisting of: a per cent of material just passing through p meshes to the inch; b per cent of material just passing through q meshes to the inch; c per cent of material just passing through r meshes to the inch; and this be ground down to a product consisting of: d per cent of material just passing through s meshes to the

TABLE 1.

Number of Meshes Per Linear Inch.	Diam. of Aperture Inch.	Reciprocal of Diameter.
5	.1000	10.00
8	.0620	16.13
10	.0500	20.00
12	.0416	24.04
16	.0312	32.05
20	.0250	40.00
25	.0200	50.00
30	.0166	60.24
35	.0142	70.42
40	.0125	80.00
50	.0100	100.00
60	.0083	120.48
70	.0071	140.84
80	.0062	161.29
100	.0050	200.00
150	.0033	300.00
200	.0025	400.00

inch; c per cent of material just passing through t meshes to the inch, the work done in grinding may be found by first of all computing the work required to reduce the feed down to some very small uniform size of, say, m meshes to the inch, next computing the work required to reduce the product of the machine down to the same size of m mesh, and then subtracting the two. That is to say, the total work done in the machine is proportional to

$$a(m-p) + b(m-q) + c(m-r) - d(m-s) - e(m-t)$$
$$= d\,s + e\,t - a\,p - b\,q - c\,r$$

because $\quad a + b + c = d + e = 100.$

This gives us, then, a very simple rule for finding the work done in a grinding machine, which we may best describe by a numerical example. Suppose that we wish to compare the efficiencies of the grinding effected by two machines, the feed and resultant products of which grade as in Table 2.

TABLE 2.

	Mch. A otpt., 20 tons a day.		Mch. B otpt., 17 tons a day.	
	Feed. Per ct.	Prodt. Per ct.	Feed. Per ct.	Prodt. Per ct.
Through 20 and on 40..	10.3	....	.5	....
Through 40 and on 60..	18.7	....	5.8	....
Through 60 and on 80..	23.5	....	29.6	....
Through 80 and on 100..	12.2	4.3	31.3	....
Through 100 and on 120..	18.6	19.7	14.7	6.2
Through 120 and on 140..	10.4	28.6	8.2	12.5
Through 140 and on 160..	4.8	21.7	7.9	47.2
Through 160.....	1.5	25.7	2.0	34.1

TABLE 3.

Multiplier.	Machine A. Result of Multiplying Percentages by Multiplier. Feed.	Product.	Machine B. Result of Multiplying Percentages by Multiplier. Feed.	Product.
30.....	309	.....	15	.....
50.....	935	.....	290	.....
70.....	1,645	.....	2,072	.....
90.....	1,008	387	2,817	.....
110.....	2,046	2,167	1,617	682
130.....	1,352	3,718	1,066	1,625
150.....	720	3,255	1 185	7,080
180.....	240	4,626	360	6,138
	8,345	14,153	9,422	15,525
		8,345		9,422
Units of grinding per ton.....		5,808	Units of grinding per ton.....	6,103

We have then to multiply each percentage by the number of meshes to which it corresponds. Thus, the material passing through 20 mesh, and caught on 40, will be considered to correspond to an average size of 30 mesh, and the percentage of this class of material is accordingly multiplied by 30. Regarding the material that passes through 160 mesh as equivalent to an average size of 180 mesh, we may arrange the computation as in Table 3.

Thus the total work done in crushing by Machine A is proportional to $5{,}808 \times 20 = 116{,}160$, and that by Machine B to $6{,}103 \times 17 = 103{,}751$, and the crushing efficiencies of the two machines are in the proportion of 116: 104, nearly.

The theory underlying this method is in general accordance with the tests of Von Reytt, quoted in Richards' "Ore Dressing," Vol. I, page 305.

EXTRACTION OF URANIUM AND VANADIUM.*

When the mineral carnotite was first discovered in the western part of Colorado, we had the first example of the two elements uranium and vanadium occurring together in the same mineral, except in mere traces. In this locality the mineral carnotite was found in commercial quantities and the economical treatment of the same became a pertinent question. At that time there was a strong demand for uranium with a very weak and fluttering market for vanadium, consequently all efforts at first were bent solely on the recovery of the former, and no attempts were made to save the latter. Later, when both the demand and price of vanadium had made it more alluring, attempts were made to separate and save the vanadium content. The first products obtained were a very complex composition and contained both the uranium and vanadium. The buyers of this product, however, would only pay for one of the elements present, and when sold to a uranium buyer, as was invariably the case, the vanadium was not paid for. This meant but one thing—in order to realize the entire value of the ore, it was absolutely necessary to separate the two elements and ship two distinct products.

The first attempts to treat this ore were made in the spring of 1902, when two Frenchmen forming the firm of Poulot & Volleque, built a small mill in Colorado, on the Dolores River, about 4 miles below the mouth of Disappointment Creek.

Poulot & Volleque decided to sacrifice the vanadium in the ore and to work entirely for the uranium. Their method consisted in grinding the ore to 20 mesh by means of a Krupp ball mill, breaking up and dissolving the values by means of a percolating solution of sulphuric acid. The filtered solution contains, beside the uranium and vanadium, all of the iron and lime in the ore. The solution was then treated with a calculated quantity of sodium carbonate, the effect of which was to precipitate all the metals carried by the acid; i. e., uranium, vanadium, iron, and lime. This precipitate, carrying approximately 16 per cent to 18 per cent uranium oxide, was the final product and was shipped to Germany for refining. The disadvantages of this process are: The vanadium is lost, as the buyers refuse to pay for it in combination with the uranium; the uranium commands a very low price on account of the impurities present; the cost of chemicals is excessive, the sulphuric acid cost amounting to over $20 per ton of ore treated; further treatment of the product is required. The eventual result of these was that only the highest grade ore in the camp could be profitably treated, and when this was exhausted, the plant was forced to shut down.

Poulot & Volleque fully realized the deficiency of their process and set to work to rectify it by means of separating the uranium and vanadium, making two distinct products which would increase the income from the ore, but they were unable to take any decisive steps toward cutting down the costs. Their new method, commonly known as the Poulot process, started in by extracting the vanadium by the old German method of roasting with salt and lixiviating with water, later precipitating the vanadium with lime. (Ferrous vanadate can be obtained at this point by substituting ferrous chloride or other ferrous salt for lime.) This gives the vanadium in the form of calcium vanadate, practically free from uranium. The uranium does not form a compound soluble in water on roasting with salt, and the separation between the two elements is made at this point. In fact the uranium combines with the salt to form sodium uranate, $Na_2O.3UO_3$, which is extremely insoluble except in acids, after which it must be precipitated with some alkali, either sodium carbonate or sodium hydrate. Poulot's plan was to dissolve in acid and precipitate with sodium carbonate, adding an excess to redissolve the uranium as double carbonate of sodium and uranium, $2Na_2CO_3.UO_2CO_3$, then precipitating the uranium as sodium uranate with sodium hydrate. The redissolving with sodium carbonate is to free the uranium from iron and lime which of course are insoluble in carbonates. This process still has the disadvantage of requiring an excessive amount of chemicals (sulphuric acid) and the cost is therefore prohibitive. For this reason the mill was not operated on this method by Poulot & Volleque, but after lying idle for 2 years was leased by the Western Refining Co., which attempted to use it. This resulted in a complete failure, due to the scarcity of high-grade ore, the extremely high cost of treatment, and, in addition to the above, decidedly poor management.

The next parties who tried to work these ores, organized the Dolores Refining Co., built a mill about a quarter of a mile above the old Poulot & Volleque mill and installed the Engle-Haynes process, described in Mineral Resources of the United States, 1906, page 531. This process, which is patented, is based on the fact that both the uranium and vanadium in carnotite are easily soluble in a hot solution of sodium carbonate, the uranium forming the double compound, sodium-uranium carbonate, $2Na_2CO_3.UO_2CO_3$, and the vanadium forming the compound sodium vanadate, Na_2VO_4. This makes a complete separation of the uranium and vanadium from the iron and lime present. The clear resultant solution after filtering is treated with sodium hydrate which precipitates the uranium as the yellow sodium uranate, $Na_2O.3UO_3$, carrying about 67 per cent uranium oxide. This is filtered off and the vanadium precipitated out of the filtrate as calcium vanadate, $Ca_2(VO_3)_2$, by the addition of lime. This process has since been improved so that ferrous vanadate can be obtained directly, and lime is not used at any point. After precipitating the vanadium the solution consists of nearly pure sodium hydrate. The solution is then recarbonated and used

*Abstract from a paper by Justin H. Haynes in Mines and Minerals.

on fresh ore. One of the difficulties encountered in the practical work is the formation of an enormous quantity of a very troublesome collodial slime, and the ore is usually put through a preliminary roast without the addition of chemicals to coagulate this slime.

The gases from the roaster are used for recarbonating the solution. This process is the cheapest and most practical that has so far been installed, as the reactions are simple, the chemicals used are among the cheapest possible, and the solutions are reused. The only chemicals consumed amount to those lost mechanically and shipped out combined with the two products.

Another process for treating carnotite has been patented (June 9, 1908) by Messrs. Fleck & Haldane. According to the patent specifications their process is as follows: "The ore is crushed, preferably to 20-40 mesh, by any suitable means, and is then agitated with hot sulphuric acid of 15-20 per cent concentration, the proportion of acid used depending upon the quality of the ore—as a rule 400 pounds of sulphuric acid of 65° Baumé, diluted to 15-20 per cent, will be found sufficient for the treatment of 1 ton of ore. The resulting acid solution contains the uranium, vanadium, and copper values and is preferably filtered or otherwise clarified. The resulting clear acid solution is then brought in contact with fresh ore, being preferably heated and agitated in contact therewith, whereby the solution is neutralized. At the same time a part of the uranium, vanadium, and other values, frequently accompanied by iron, is precipitated upon the ores as basic sulphates or carbonates, the effect of this precipitation being to enrich the ore which may be initially of a low grade. The neutral solution is again clarified if necessary and constitutes a portion of the stock solution suitable for further treatment for the separation of the values described below. The enriched ore which has served for the neutralization of the acid solution, either alone or mixed with fresh ore, is treated with sulphuric acid as above described, yielding an acid solution, which after neutralization is added to the stock solution. The ore residues from the treatment with sulphuric acid, as well as the residues from the similar treatment of the enriched ore, are freed from the remaining values by washing with dilute sulphuric acid or acidulated water. The resulting acid washings are then strengthened by the addition of sulphuric acid to a preferred concentration of 15-20 per cent and are utilized for a continuance of the process.

"The reduced, and substantially neutral solution, is separated from the ore, clarified if necessary by filtration or decantation, and treated with a calculated quantity of finely pulverized limestone or equivalent carbonate to bring it to the point where uranium, vanadium, and copper values would just begin to separate, calcium sulphate being formed. The solution is now separated from the calcium sulphate, and the values completely precipitated by boiling with the requisite quantity of pulverized limestone. The precipitate, which comprises a complex mixture containing basic sulphates and carbonates of uranium and vanadium, compounds of iron, and hydrated calcium sulphate, is initially green but changes rapidly in the air to light green or yellow. It may be profitably shipped, preferably after drying or drying and igniting to effect a further concentration of the values. Or the values may be further refined or concentrated by any known or suitable method."

The exportation of gold from British South Africa in 1908 increased from about £29,500,000 to about £32,000,000; on the other hand, the value of the exportations of diamonds fell from £8,973,148 to £4,786,555; although about the same weight, say 4,400,000 carats, was exported in each of the 2 years. This is to be considered as due to the increased production of low-value stones, also to the lower prices prevailing in 1908. As the effects of the American crisis made themselves felt in the diamond trade, the mines near Kimberley reduced their output and sales materially; and what were produced in the months from February to June were simply kept on hand. For this reason they exported in 1908 only 1,634,159 carats, as against 2,476,855 in 1907; and by this means succeeded in maintaining the prices of the better grades of diamonds, which are principally produced in the Kimberley district. The Premier Mine in the Transvaal, on the other hand, increased the low-grade productions, which had the effect of reducing the prices of such stones. The small exportation of valuable stones and the lowering of the price of the inferior ones account for the remarkable fact that the statistics in the two last years show the same weight of stones exported, while the value of the exportation in 1908 was only half that for 1907.

The year 1909 witnessed a wonderful revival in the iron and steel industry of the United States, and the production of the former will nearly reach the record production of 1907. According to an estimate made by E. C. Harder of the U. S. Geological Survey the production of iron ore in 1909 was approximately 51,000,000 long tons, while the production of pig iron totaled about 25,500,000 long tons. In 1907 the production of pig iron was 25,781,361 long tons, and in 1908 the production was 15,936,018. The production of iron ore in 1907 was 51,720,619 long tons; in 1908 the production was 35,983,336 long tons. Of the 1908 iron ore 28,225,412 long tons were produced in the Lake Superior District. Alabama produced 3,734,438 tons, and New York produced 607,473 tons.

The material carrying the highest percentage of cinnabar at the Nevada-Almaden mine, Humboldt county, Nevada, is found in the limestone, in connection with a soft dike which has intruded and considerably displaced the limestone. A large amount of placer gold was formerly taken from the gravels near this mercury deposit.

SAMPLING.*-

By R. DODS.

The method to be adopted for obtaining a sample will depend upon the character of the material to be sampled, and the use to which it is to be put after sampling. In obtaining a sample, the work should be fairly done—that is to say, without selection of any portion of the lot or mass. Sampling may be carried out in a great many ways. In this paper it will be my aim to deal briefly with a few methods, and explain the advantages or disadvantages of each. I will refer firstly to the

SAMPLING OF AURIFEROUS AND ARGENTIFEROUS LEAD BULLION.

Lead carrying gold and silver may be sold to refiners in bars. The assay of these alloys presents no special difficulties, but the sampling of them is a question which may be profitably discussed. A molten metal may be conceived to have all the physical states observed in ordinary liquids, although these cannot be actually seen, owing to its opaqueness. At a temperature a little above its melting point, pure lead can contain a fairly large proportion of gold in such a manner that it may be spoken of as a clear solution. Although there seems to be evidence to the contrary, it is the writer's idea that "any small portion withdrawn from this solution would afford a perfect sample." Where the silver does not exceed 700 ozs. per ton, the same would be true of any alloy of lead and silver. Zinc and copper present, to the extent of 5 per cent and 0.1 per cent, respectively, renders the molten metal turbid. Such a molten mass sampled at random may be satisfactory, perhaps otherwise. The insoluble matter in suspension tends to concentrate itself in the upper or lower parts of the liquid according to their relative specific gravities, and the separation may occur with extreme slowness or with fair rapidity. In the case of such alloys as occur in practice, I have no hesitation in saying that samples taken in this way are quite satisfactory, and are the best obtainable. When taking the sample the lead should be made as hot as practicable and stirred; any dross forming on the sufrace of the metal can be removed and separately sampled and assayed. An alternative and, perhaps, better way of taking the sample is to withdraw portions at equal intervals from the stream of metal while the furnace is being tapped, or while the pot is being emptied. This is the usual practice. Imagine such lead run into bars; the difference between bar and bar would probably not be greater than that between corresponding dip samples, but in each bar the distribution of the silver and gold is very seriously affected during solidification, as described in the experiments following. This rearrangement of the constituents of a bar takes place while the lead is partly solid, partly liquid.

Average of the Cross Section.			Results in Ozs.—Dwts.—Grains											
ozs.	dwts.	grs.	ozs.	dwts.	grs.	ozs.	dwts	grs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
60	3	14	59	11	20	60	15	16	59	11	15	60	15	7
59	17	1	60	10	17	59	1	5	59	13	4	60	3	3
59	19	0	60	10	6	59	7	13	59	1	17	60	16	12
59	16	8	60	14	3	59	2	23	59	1	16	60	6	17
59	16	6	60	7	15	59	4	4	58	19	12	60	13	17
59	12	21	60	12	7	58	13	21	59	6	10	58	18	23
59	9	23	59	16	12	59	1	7	58	10	9	60	11	18
59	14	17	60	15	2	58	15	19	59	3	0	60	5	1
59	15	0	60	11	16	59	1	23	58	16	9	60	10	0
59	16	12	60	14	9	59	0	18	59	3	6	60	7	15
59	14	16	60	6	23	59	6	11	58	18	23	60	6	9
60	1	22	60	6	22	59	14	7	60	5	1	60	1	10
Av. vertically			60	8	4	59	5	11	59	4	6	60	8	1

Average of Total Bar = 59 ozs. 16 dwts. 11 grains.

Average of the four (4) corners, A.B.C.D.
A = 60 ozs. 3 dwts. 21 grs.
Average of all the outside portions.
C = 60 ozs. 6 dwts. 12 grs.

Average of the four most center portions.
B = 58 ozs. 18 dwts. 0 grs.
Average of the two (2) opposite corner sets extending to middle of bar.
= 59 ozs. 6 dwts. 7 grs.
= 59 ozs. 16 dwts. 16 grs.
= 59 ozs. 16 dwts. 11 grs.

*Paper read before the Scientific Society of Broken Hill, Australia

Experiment Upon the Estimation of Gold in Various Parts of Bar of Auriferous Lead Bullions.—The bar was divided into 48 parts, as nearly equal as possible, and each part cupelled. The accompany table represents a tabulated copy of the experiment in the same order as in plan of the bar.

By sampling from the corner chips the result was 7 dwts. 10 grs. too high. By taking the four most central portions a result was obtained 18 dwts. 11 grs. too low. By choosing the outside portions a result was found = 10 dwts. 1 gr. too high. By sampling from the two opposite corners a result was obtained = 4 grs. too low; = 5 grs. too high.

Experiment A.—A bar of bullion was taken, heated just a little above its melting point, thoroughly stirred with an iron rod and poured into a cold mold. The bar was divided into 21 parts as nearly equal as possible. The weight of each part was taken, and they were then cupelled. Dimensions of cast-iron mold are as follows: Depth, 1/2 in.; top, 4 1/4 in. x 1 1/2 in.; bottom, 4 in. x 1 1/4 in.; thickness of bottom, 5/8 in.; thickness of ends and sides, 5/8 in. The following represents a tabulated copy of the experiment, in the same order as in plan of the bar:

Average of the Cross Section.	Results in Ounces per Ton.		
65.35	65.35	65.19	65.52
65.12	65.45	64.38	65.54
64.73	65.18	63.81	65.21
64.81	65.22	64.20	65.03
64.60	65.21	63.90	64.94
65.04	65.15	64.60	65.38
64.95	64.99	64.74	65.22
Av. vertically	65.21	64.40	65.26

Average of the total bar = 64.95 ozs. (Ag.) per ton. It will be noticed that there is regularity in these parts. The maximum difference between any two parts is 1.73 ozs. Average of all the outside portions = 65.20 ozs. Average of the three most central portions = 63.07 ozs. Average of the four corners = 65.27 ozs. By sampling from the outside portions a result was obtained 0.25 oz. too high. By sampling from the three most central portions, the result was 0.98 oz. too low. By sampling from the four corners the result was 0.20 oz. too high.

Experiment B.—A bar of bullion was taken similar to that used in Experiment A. The bullion was heated to redness, thoroughly stirred with an iron rod, and poured into a mold heated a little below redness, and then allowed to cool slowly. The bar was divided into 21 parts, and each part cupelled. A tabulated copy of the experiment, in the same order as in the plan of the bar, is as follows:

Average of the Cross Section.	Results in Ounces per Ton.		
61.79	63.74	62.56	59.07
64.33	65.51	63.94	63.53
64.03	65.86	64.09	62.16
64.53	66.15	64.57	62.87
65.02	66.54	64.46	64.07
65.01	66.51	64.95	65.38
65.74	66.44	65.63	65.17
Av. vertically	65.82	64.31	63.17

Average of total bar = 64.43 ozs. (Ag.) per ton. It will be noticed that there is no regularity in these parts. The maximum difference between any two parts is 7.47 ozs. Average of all the outside portions = 64.45 ozs. (Ag.) per ton. Average of the three most central portions = 64.37 ozs. (Ag.) per ton. Average of the four corners = 63.60 ozs. (Ag.).

SAMPLING OF FREE NATIVE COPPER METALLICS.

The term "sampling of samples," I think, illustrates its meaning. Judgment is required in preparing such samples, and the amount of work to be done can be greatly abridged by a careful study of the mineral. In preparing samples of metallics for the laboratory it is usual to reduce the copper to about the size of peas—to such a size as to enable it to pass a 1/4-in. screen. The next procedure is to subject the whole sample to a screening test. Having obtained the various sized products, each portion is weighed separately to determine what percentage it bears to the whole sample. Having determined the proportion of the total weight on each screen (expressed as a percentage), a number of grams equal to its percentage is taken from each screen. This gives a sample of 100 grams. As an example:

Supposing result of screening showed: (a) On 10-in. mesh = 10%; (b) on 20-in. mesh = 10%; (c) on 40-in. mesh = 10%; (d) on 60-in. mesh = 10%; (e) on 80-in. mesh = 10%; (f) through 80-in. mesh = 50% by weight.

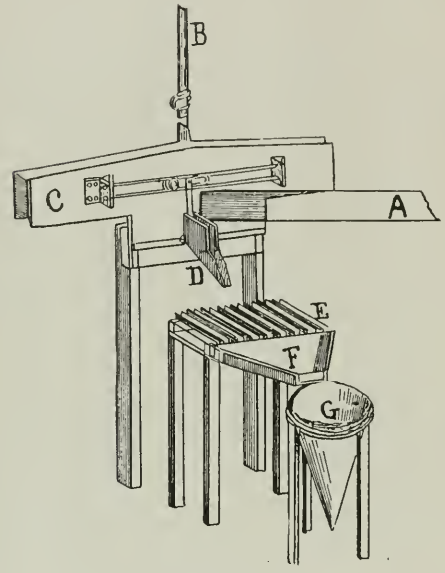
Take 10 grams of each of the following products: On 10-in. mesh, on 20-in. mesh, on 40-in. mesh, on 60-in. mesh, on 80-in. mesh, and from the product through 80-in. mesh take 50 grams.

If a 50-gram sample is required, take half the number of grams from each product. To assay this product for copper, the whole of the 50 grams is placed in a tall, conical beaker, covered with watch-glass, and digested with dilute nitric acid (HNO_3), until solution of the copper is apparently complete. Solution is decanted through a filter residue, washed and ground up in agate mortar, and again digested with diluted nitric acid (HNO_3) to recover last trace of copper. The resulting solution from this latter treatment, after being filtered, etc., is added to the main bulk. This solution is now diluted to 1,000 cc. with water, and 10 cc. taken for assay, which is equivalent to 0.5 gram of copper.

AUTOMATIC SAMPLING.

"Lamb's Tailings Sampler" is one that may be recommended. This sampling machine has been designed to obtain accurate sample of the tailings discharged from the mill—something that would be reliable in operation, automatic, simple in construction and accurate in results—the main idea being to intro-

duce a device to obviate the hand sampling by mill men or foremen, who might have reasons for favoring results in sampling, and also to take a sample regularly at such stated intervals as may be desired, which latter is seldom attained in mill work, for many well-known reasons. With this sampler placed below the final discharge of tailings sluice, and enclosed in a small building under lock and key, it can be made accessible to only one person, and accurate samples are bound to follow. As the whole discharge of tailings from the mill does not pass through the sampler, there is not the wear on it that there is on machines or devices that have to carry the whole stream. This sampler has been in operation in one of the largest and most complete concentrating mills in the West,



Sketch of Sampler.

and, during a period of 12 mos., many comparative tests with hand sampling have been carefully made, and the results have proven that this device is reliable and accurate in its work. Its simplicity of construction, small liability of getting out of repair, together with its low cost, I believe, makes it a most desirable appliance for this work.

Adaptability.—This sampler can be applied to any mill, regardless of the process employed for treating the ore, with the single proviso that the tailings from the mill are discharged by means of a sluice box, to which the sampler could be attached.

Details of Construction.—By referring to sketched drawing, in conjunction with the following description, the details of construction will be more readily understood: *A* represents a "tailings sluice" running out of the mill; *B*, "water pipe" for filling balance box; *C*, balance (or tilting) water box. This is a double-compartment box, arranged with a partition in the center, so that when one side has filled and is discharging, the other side is being filled. Attached to the front of the balance box is the track for carrying the sampling spout (*D*).

(*D*) Sampling Device.—This consists of a narrow spout or trough, suspended from a hanger or carriage having two grooved pulleys which run on the track attached to the balance box. This spout and carriage works by gravity, and, as the balance box discharges at either end, the spout travels across the face of the stream. This gives an accurate sample of the tailings, as it takes an equal amount right across the sluice, and also includes a proper proportion of the slimes, as well as the fine and coarse sands.

(*E*) Divider or Reducer.—This consists of a number of small troughs, made preferably with a V bottom and vertical sides, the sides being high enough to prevent the slimes or lighter material from slopping out. These troughs rest loosely in a notched rack, and are set at a pitch that will give a free discharge on the apron below. By varying the number of troughs employed the volume of the sample can be regulated as desired.

(*F*) Apron on to which the dividers (*E*) discharge, and by means of which the sample is conveyed to the filter sack.

AUTOMATIC SAMPLER.

Filter Sack.—This is simply a canvas duck sack, which permits the surplus water to be drained off. In place of the filter sack, a series of overflow tanks may be used.

The water from the feed pipe discharges into the upper half of the balance or tip box. When the weight of water accumulated in this compartment equals or slightly exceeds the weight of the traveling trough, the balance box tips and the traveling trough moves along the inclined rods, sweeping across the stream of tailings at right angles to its course, cutting out an equal proportion of the full width of the stream, and taking an actual proportionate amount of coarse, fine and slimes tailings. The traveling trough moves over and across a series of V troughs, with open spaces between discharging the sample cut out into these troughs, the excess falling through the open spaces between them. The V troughs discharge onto an apron, which in turn discharges into the final receptacle, the filter sack. Beneath the filter sack is placed a box for receiving the filtered water from sampler. This is a guard against imperfect filtering or leakage, as well as means of testing such waters for any values that may be soluble. With this sampler the feed water to balance or tip box can be regulated by a valve, so that a sample can be taken at any interval of time desired, or for a 24-hr. run (if only a daily sample is to be taken), can be regulated by increasing or decreasing the V troughs into which the traveling trough discharges its contents. If the machine is kept well oiled it will do its work faithfully.

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NOTES AND COMMENTS.

CHARLES BENJAMIN DUDLEY.

In the death of Dr. Charles B. Dudley, which occurred on December 21, 1909, at his home in Altoona, Pa., the chemical profession in America sustained a signal loss.

Dr. Dudley's death was the result of a brief but unusually severe attack of pneumonia and came as a distinct shock to his brothers of the chemical profession. For thirty-four years Dr. Dudley had been at the head of the chemical and experimental laboratory of the Pennsylvania Railroad. This laboratory he organized and developed, and his work there had not only an important effect upon the service of the Pennsylvania Railroad, but also was of such a character as to prove conclusively to other corporations the value of chemical knowledge when applied, not only to the testing and analysis of the materials they purchased, but also to the solution of many of the problems with which they were confronted.

Dr. Dudley may be looked upon as the founder of engineering chemistry in this country, and no one man has contributed more to our knowledge of the chemistry of engineering materials than has Dr. Dudley. His experiments cover a wide range and his investigations were conducted upon many materials. His studies upon the characteristics of steel began almost at the outset of his connection with the Pennsylvania Railroad, and revolutionized railroad construction. This work, while it drew upon him the hostility of many steel makers, greatly increased the safety of the traveling public and soon made it evident that his field for usefulness as a railroad chemist was not to be confined solely to the economic purchasing of materials but also to promoting efficiency and safety in transportations.

Dr. Dudley was born at Oxford, N. Y., July 14, 1842. His boyhood was spent in this little village and he was educated at the local school and academy. When the war broke out he enlisted in the 114th Regiment of New York Volunteers. At Opequan Creek, in 1864, he was wounded in the leg, and from this injury he limped to the day of his death. Upon his return home in 1865, he renewed his preparation for college at Oxford Academy, and thereafter graduated from Yale College with the degree of A. B. in 1871. After spending a year upon a New Haven newspaper, he spent two years of study at the Scheffield Scientific School of Yale University. At the end of this period he was awarded the degree of doctor of philosophy. For a year Dr. Dudley acted as assistant to Prof. George F. Barker, in the Department of Physics at the University of Pennsylvania, and the following year he was offered the position of chemist with the Pennsylvania Railroad, a position which he held continuously to the time of his death. He was married, April 17, 1906, to Miss Mary V. Crawford, who survives him.

Among his important scientific labors has already been mentioned his efficient service with the Pennsylvania Railroad. This was, however, but a part of Dr. Dudley's life work. The scientific periodicals are filled with the published results of his labor, which was extensive and covered almost the entire field of engineering chemistry and the testing of structural materials.

Dr. Dudley was a charter member of the American Chemical Society, and was from 1896 to 1898 president of this society. He was at the time of his death, and had been since 1902, president of the American Society for Testing Materials. At its recent meeting he was elected president of the International Society for Testing Materials. He was also president of the Bureau for Safe Transportation of Explosives of the American Railroad Association and was a member of the Iron and Steel Institute of Great Britain, the American Institute of Mining Engineers and a large number of other national and foreign technical societies. Much of the success of the American Society for Testing Materials was due to his services as president. His presidential addresses before this society were notable for their breadth, fairness, thoroughness of treatment and saneness. He was a man of great personal magnitude and much enthusiasm, whose views were always respected, even by those who did not agree with him.

Dr. Dudley will long be remembered as a leader in the technical application of chemistry to the great industrial problems of the day, and it is regretted that in his busy life he could not spare time to gather together all of his writings and compile therefrom a monumental and authoritative work on engineering chemistry.

Oxygen Blast.

In a recent paper on the industrial application of oxygen and liquid air, delivered before a body of French engineers, Geo. Claude, a French engineer, announced that an experiment is soon to be made on a large scale by a Belgian iron and steel plant, the Societe d'Ougree Marihaye, with respect to the enrichment of air with oxygen for the blast in one of their furnaces and converters.

Mr. J. E. Johnson, Jr., an American engineer, some time ago in a paper read before the American Institute of Mining Engineers proposed substituting oxygen for air in the blast furnace. The principal gain of this process would be the possibility of doing away with

the hot blast stoves and accessories. Mr. Johnson proposes another radical feature in connection with his system; namely, that of feeding the carbon and the iron ore in separate columns instead of together, as at the present time. The proposition is to oxidize the carbon by the oxygen blast to carbon monoxide and to force the carbon monoxide through the iron ore, resulting in the reduction of the ore and the formation of carbon dioxide. The latter is then passed through the ore column, and preheats the latter. Owing to the fact that this carbon dioxide does not come in contact with free carbon, it is not reduced again to the monoxide and consequently more of the carbon can be oxidized than is now done in the ordinary blast furnace, and hence a better utilization of the fuel value of the coal can be obtained.

The Automobile and the Gas Manufacturer.

At first sight there seems to be little relation between the automobile and the gas industry. As a matter of fact, the relationship is becoming very close. The advent of the automobile has changed very materially the character of the traffic over our roads. The rubber tires have a very different effect upon the roadbeds from the old-fashioned iron tires. The great tractive force exercised by the rear tires of motor vehicles is the main cause of the destruction of the surface of the road. This is due to the fact that there is a perceptible slip of the driving wheels of the automobile and consequently a shearing off of the surface of the roadbed. This action tends to throw into the air large quanties of surface material from the roadway. This dust is taken up by the wind and carried into the nearby fields instead of being deposited again in the roadway. This dust not only proves a source of great inconvenience to those living near the public highways, but the continual wearing away of the roadway necessitates frequent replacement of top dressing and consequently increased cost of maintenance of the public highways.

A great many materials have been proposed and tried to lay the dust. Among the most prominent of these are crude oil and tar. The latter has been employed for many years and tar Macadam roadways date back to the early part of the last century. The spraying of tar upon Macadam roads already constructed is in this country comparatively new, but abroad it had been employed for a good many years. At the present time coal tar is obtained quite extensively as a byproduct in the manufacture of illuminating gas. The value of this material has not been great and in a good many instances there has been no profit in its collection. The general use of coal tar on roads would unquestionably open up a splendid field to the gas manufacturer, and enable him to get rid at a reasonable price of one of his most voluminous byproducts. To show the possibilities along this line, the state of Maryland is about to let one contract for 180,000 gallons of tar, which will be used on a single stretch of road, eight miles in length.

BOOK REVIEWS.

Chemical Conversion Tables for Use in the Analysis of Commercial Fertilizers Cotton Seed, Iron and Food Products, etc. H. B. Battle, Ph. D., and W. J. Gascoyne, Ph. D. 12vo. Leather. 78 pages. Thumb Index. Price $2.50. Williams & Wilkins Pub. Co., Baltimore, Md. 1909.

This little book is a successor to the original "Chemical Conversion Tables," published in 1885, by H. B. Battle and F. B. Dancy, at that time chemists in the North Carolina Experiment Station, at Raleigh.

The present work consists of thirteen tables, ten of which are for converting one chemical compound into another. The tables are as follows: Phosphoric Acid, Potash, Ammonia and Protein, Nitrogen, Chlorine, Sulphur, Alumina, Phosphorus and Magnesia, Silicon and Manganese. Other tables give the Atomic Weights for 1909, Conversion Factors of 312 compounds and for Converting Weights and Measures from one system to another.

The volume is thumb indexed so that ready reference can be made to any table. These are quite extensive and are carried out sufficiently far for all practical work. They will no doubt prove of great assistance to all analytical chemists engaged in the analysis of fertilizer materials. They should also prove of assistance to many chemists engaged in other lines of work, in which the above compounds are determined.

Technical Calculations for Sugar Works. By Otto Mittelstaedt. Translated by C. J. Bourbakis. 12vo. Cloth. XI—117 pages. Price $2.00. John Wiley & Sons, New York. 1910.

This little book is intended to instruct the chemist as to the application of the results obtained from his analyses to the control of factory work. The fact that the book has passed through three German editions is sufficient evidence that it has been successful in its field. The present edition has been completely rewritten and enlarged. The translator has done his work well and the printer and binder have presented the material attractively. The book is divided into five parts, the first of which is devoted to "Fundamental Notions," and treats of sugar, non-sugar and coefficient; losses in manufacture and yield. The second part is devoted to "General Methods of Calculation." The third to the "Theoretical Calculation of the Work of a Raw Sugar Factory." The fourth part treats of the "Calculation of the Work of the Refinery" and the fifth part of "The Sugar Factory." The book should prove a welcome contribution to the short list of books on the sugar industry already obtainable in English.

Quantitative Chemical Analysis. By Frank Clowes and J. Bernard Coleman. 8vo. Cloth. Illustrated. XXIV—565 pages. Price $3.50. P. Blakiston's Sons & Co., Philadelphia, Pa. 1909.

The eighth edition of this standard work on Analyti-

cal Chemistry has been rearranged and a change in the size of page from 5½x7¾ to 6¼x9 inches has made resetting of the type necessary, and hence has allowed a complete revision of the whole text. Considerable addition has been made to the subject matter and a number of new cuts appear. The increasing of the size of the page has allowed this matter to be incorporated without increasing the number of pages. Among the newer material which will be found in the present edition we note some new methods for the determination of melting and boiling points, for the electrolytic estimation of metals; for the volumetric determination for hydrogen peroxide, formaldehyde, silver, and of tin and antimony in alloys; for the estimation of preservatives in milk and butter, resin acids in soap, and poisonous metals and dissolved oxygen in water. There are also additional methods for the valuation of the ores of chromium, tin, arsenic, mercury and zinc. A new section has been introduced on the examination of oils, fats and waxes and a table of the constants and characteristics of the ordinary members of this class of substances has been inserted, by means of which the results of the examination may be interpreted. This table has been inserted through the kindness of Dr. Lewkowitsch. The section on the Valuation of Tanning Materials has been revised by Prof. Leeds.

The book is one which will be found of service to chemists engaged in analytical work. The methods are clearly described and for the most part are satisfactory. The work has been used extensively as a text-book, both abroad and in this country, and is unquestionably an excellent laboratory manual.

Transactions of the American Institute of Chemical Engineers. Vol. I. 1908. 8vo. Cloth. Illustrated. 204 pages, with plates. Price $5.00. D. Van Nostrand Co., New York. 1909.

The first volume of the transactions of the American Institute of Chemical Engineers contains an account of the various steps which led up to the formation of the Institute and the full text of the papers read at the first meeting of the Institute.

The volume opens with a short history of the Institute since its inception. This is followed by the minutes of the meeting held in Philadelphia, June 22, 1909, for the organization of the Institute and the full text of Dr. Charles F. McKenna's address, presented at that time, on the "Justification of the American Institute of Chemical Engineers." This is followed by the constitution and by-laws of the Institute and the minutes of the first annual meeting held in Pittsburg, Dec. 28 and 29, 1908.

The papers read at the Pittsburg meeting comprise the following: The address delivered by the President, Prof. Samuel P. Sadtler, on "Some Thoughts on the Organization of the American Institute of Chemical Engineers"; "Steam Power Plant Economies", by Wm. M. Booth; "Testing and Performance of Steam Generating Apparatus", by A. Bement; "The Examination of Flue Gases in Boiler Tests", by H. August Hunicke; "Heating of Industrial Furnaces With Pulverized Fuel", by Richard K. Meade; "Modern Electrical Resistance Pyrometry", by Edwin T. Northrup; "Chemical Specifications for Sulphite Pulp", by J. A. Decew; "Purity of Commercial Liquefied Ammonia Gas and Apparati for Testing It", F. W. Frerichs; "The Sanitary Condition of the Southern End of Lake Michigan", by J. Herbert Brewster; "The Ferric Iron Contact Process of Making Sulphuric Acid from Smelter Fumes", by Thorn Smith and "Calculations for Dryer Design", by Wm. M. Grosvenor.

The volume also contains a list of the officers, committees and members of the Institute.

REINFORCED CONCRETE CYANIDE VATS.

In a paper on "The Application of Concrete in the Metal Mining Industry," appearing in the *Engineering Magazine*, Mr. Henry W. Edwards calls attention to the use of reinforced concrete cyanide vats in the cyanide treatment of gold ores. He says: "In the making of tanks for water or for the cyanide process or for slime settlers, reinforced concrete is most adaptable. Recent changes in the manipulation of the cyanide process have involved the use of tanks which rather puzzle the wooden tank manufacturer, particularly those tanks with conical bottoms. The maker's difficulty in these tanks comes in keeping the hoops from slipping down the conical part, or in finding any really satisfactory substitute for hoops. For the concrete man these difficulties do not arise; he has no bounds of shape nor size nor position, nor is he called upon to handle material of unusual dimensions, nor, like the iron tank man, is he obliged to send a gang of riveters, say from Pittsburg to Nicaragua, to rivet up a set of tanks shipped in sections.

"Another essential part of the cyanide plant is the system of launders or troughs for conveying the solutions from tank to tank. When made of wood these launders are not difficult, so long as they are straight; but when curves or junctions become necessary, then the difficulties of making them absolutely watertight begin. Concrete launders can be made as complicatedly crooked as may be convenient, with perfect freedom from leakage, and, moreover, if allowed to dry, they do not shrink, like wood, opening up cracks where none previously existed.

"The former method of building cynaide tanks was by lining, with heavy concrete excavations partly or wholly below ground level. The modern reinforced concrete cyanide tank is an elevated structure upon concrete pillars, with its bottom and all its other parts as accessible to inspection and repairs as an iron or wooden tank. In the modern construction of cyanide tanks 'expanded metal' or a system of iron rods and wires forms the reinforcement; the concrete, some 6 inches in thickness, is thoroughly troweled over with neat cement on the inside in order to close up the pores of the concrete.

INDUSTRIAL AND PLANT NEWS.

Asbestos.—The International Asbestos Association, which was organized in New York recently, is composed of representatives of between 80 and 90% of the United States and Canadian Asbestos mine owners and manufacturers. Included in the Association are: Amalgamated Asbestos Corporation, Ltd., Keasbey & Mattison Co., Philip Carey Mfg. Co., Asbestos Protected Metal Co., Franklin Mfg. Co., H. W. Johns-Manville Co., Sall Mt. Asbestos Mfg. Co., Ling Asbestos Co., and the United States Asbestos Co. The aggregate capitalization of the concerns which are so far represented is over $40,000,000. The following were elected officers of the association: T. F. Manville, president; R. V. Mattison, Jr., vice-president; R. P. Doucet, secretary.

It is announced that the purpose of the association is the general exploitation of the uses of asbestos, particularly in the field of fireproof construction, co-operation between consumer and producer, cultivation of new markets, and development of processes whereby the wastes in the industry may be rendered commercially valuable.

Brick.—The C. P. Mayer Brick Company, Park Building, Pittsburg, will erect two additional kilns at its plant at Bridgeville, Pa., and will install other improvements which will increase the capacity of the plant to 50,000 brick daily.

Fertilizers.—The F. S. Royster Guano Co., Norfolk, Va., have purchased about 20 acres with 500 ft. water front at Baltimore, and will erect thereon a fertilizer plant, including a sulphuric acid works, which is expected to make about 75 tons of sulphuric acid a day. Construction will commence at once, and the company hopes to have the plant in operation by the 1st of August. This will make the seventh plant of this concern, all of which are situated in the agricultural part of the South.

Iron.—On Feb. 8th, the new blast furnace of the Southern Iron & Steel Company, at Alabama City, Alabama, was blown in, and in about a week or ten days therefrom the steel plant of the concern will be started up. In March the new steel rod, wire and nail mills at Alabama City will be put in motion.

Leather.—The J. H. Ladew Company, of Newark, N. J., will start work in February on a new plant to be located at Kearny, N. J. The factory will be located on the Passaic River, adjoining the Newark Plank Road. It is estimated that the construction of the plant will cost $115,000.

Molasses.—Penick & Ford, Ltd., will erect a molasses refinery in New Orleans. The plant will occupy a site of eight or ten acres on the river front. Among other things the plant will contain a cold storage department and a tin can factory. The company also contemplates building their own box factory. It is estimated that the proposed plant will cost $400,000.

Nitrate Soda.—It has been generally known for the past 20 years that nitrate exists in large quantities in the low, rolling hills along the Amargosa and Colorado Rivers. The first locations were made as early as 1883 by a desert ranchman, at the instigation of a traveling chemist who was hunting borax. A company has recently been formed in California to develop its nitrate fields. This concern owns beds situated in the extreme western part of San Bernardino County between Needles and Parker in the Chemehuvis Valley, 32 miles south from Needles. The property consists of about 12,000 acres.

Oil.—The Texas Oil Company, in which Lima, O., and Pennsylvania capitalists are interested, has completed plans for the erection of a refinery at Tulsa, Okla.

Porcelain.—After several months' negotiation the Superior porcelain plant of New Cumberland, W. Va., was sold February 8th to the United States Porcelain Company, of Findlay, Ohio. The latter's plant is to be abandoned and its entire equipment removed to New Cumberland. The product of the plant is electric porcelain supplies.

Portland Cement.—The Clinchfield Portland Cement Corporation has been organized to build a plant at Kingsport, Tenn. The buildings will be of concrete and steel equipped with machinery for a daily output of 3,000 barrels. It is expected that the plant will be ready for the manufacture of cement by next January.

Steel.—The 15-ton Heroult electric furnace of the United States Steel Corporation at South Chicago has been in continuous operation since last summer, and a second Heroult furnace of the same capacity at the Worcester works was stated in January, and is reported to work very satisfactorily. While at South Chicago the electric furnace is used for refining molten Bessemer steel, open-hearth steel is electrically refined at the Worcester plant. The product is used chiefly for steel wire.

Steel.—C. W. Leavitt & Company announce that they have closed their second American contract for the installation of a Girod electric steel refining furnace.

Steel.—The Electric Steel Company of Canada proposes to establish a plant at Welland, Ontario. It is stated that work is to be begun on the billet-mill at once. Additional mills will probably be erected next year for making finished products in iron and steel.

Steel.—It is announced from Steelton, Pa., that the Pennsylvania Steel Company is now producing nickel-chrome steel from its new Cuban ore. The duplex process is being utilized at the steel plant. The product is structural material and rails. The new steel was experimented on about a year ago and contains a high percentage of chromium. The Cuban ore is said to give particularly good results in this connection.

Sulphric Acid.—See Fertilizers.

The United Indurated Fiber Co. of Lockport, N. Y., which was recently acquired by the H. W. Johns-Manville Co., will let contracts soon for construction of three two-story reinforced concrete factory buildings, each 100x200 ft., for the manufacture of asbestos articles. The cost of the improvements, including the machinery to be installed, will, it is stated, approximate $900,000.

The Titan Steel Casting Co., Newark, N. J., recently incorporated with a capital stock of $1,000,000, has purchased and succeeds to the business of Benjamin Atha & Co. The officers of the Titan company are: President, Benjamin Atha; vice president and general manager, Louis A. Shepard; treasurer, Henry G. Atha; secretary, C. W. Owston, Jr. The Titan company will continue to operate the plant as in the past, giving special attention to the production of cast steel bolsters, manganese steel railway motor gears and pinions, and other car and locomotive castings.

The American Thread Co. of Willimantic, Conn., is to erect an addition for a bleachery to its Willimantic mills in the spring near the No. 6 mill. The new building, which will be three stories high, 76x223 ft., will have rooms for the offices of the superintendent of the finishing department and the cost department, which will be moved from the No. 1 mill. The latter mill will be given over to the shipping department and the storage of finished stock.

At the January meeting of the Institution of Mining and Metallurgy, Bede Collingridge contributed a paper describing a method of testing cyanide solutions for protective alkalinity. He has found that the potassium iodide used as an indicator vitiates the test by showing apparently more alkalinity than is present. Indeed, it shows the presence of protective alkali when none is actually there.

The mineral output of Japan for the first eight months of 1909 was as follows: Gold, 1,159,754 grams; silver, 27,092,700 pounds; iron, 68,733,491 pounds; coal, 8,426,517 tons; petroleum, 42,520,285 gallons; sulphur, 30,684,150 pounds; copper, 57,335,816 pounds.

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OIL AND GREASE EXTRACTION.*

By WILLIAM MILLER BOOTH.

Consulting Engineer and Chemist, Dillaye Bldg., Syracuse, N. Y.

A certain percentage of fat is found in nearly all animal and plant structure. In many instances nature provides a special tissue or reservoir for storing energy in this way, in others fat is secreted to serve as a lubricant for the tissues themselves.

The extraction of animal and vegetable oils has been general among all races and from very early times. In its simplest forms, the fat carrying globule has been separated from its enveloping tissue by heat and pressure. Whale blubber, fish oil and many of the oils of the tropics yield to this treatment. The modern development of the art has been toward high temperatures and extreme pressure. Steam is well adapted to the first form of treatment, the hydraulic press to the latter. In some instances, centrifugal machines are used to good advantage both with and without heat.

Traffic in fat bearing materials has resulted in a demand for the exact estimation of the fat itself. The Soxhlet apparatus and its variations are universally used by practical chemists. In this way, appropriate solvents have been applied where found most available. Wide variations exist between the best results obtained by heat and pressure and those found possible with solvents. Indeed from 5% to 20% of the fat remains in the cake or scrap unless a solvent is used for extraction. With linseed oil, cotton oil or corn oil the use of the cake for feeding purposes does not require close separation. Where the pressings are thrown away or burned, a large percentage of residual oil is wasted. Due to these conditions, engineers have applied variations of the Soxhlet extractor to the needs of the manufacturer, reproducing the glass cylinders and tubes with metal pipes and tanks, sometimes on an enormous scale. Extraction tanks are now in use, capable of accommodating a charge of 10,000 gallons of naphtha at one charge. Nearly three hundred patents have been granted for machines and apparatus dealing with extraction and kindred processes.

*Paper presented to the American Institute of Chemical Engineers, Dec. 10, 1909.

A practical solvent for fat extraction must fulfill certain conditions. It must be inexpensive and must be easily obtained in large quantities. It should be distilled by steam at or under 60 pounds pressure which requires a fluid of low boiling point. Many fats decompose when heated. As their acids are corrosive, the metal apparatus itself is rapidly destroyed. A suitable extractive material must be capable of complete separation from the fat extracted and finally it must not leave taste or odor in the fat itself. An additional advantage of a low boiling point solvent is economy in heat as less B. T. U. are required. Other conditions being approximately equal, a solvent should be non-combustible.

The fluids ordinarily used for fat extraction are naphtha, benzol, carbon disulphide, chloroform, ether and carbon tetrachloride. We have arranged a table showing the cost of the above solvents, per pound, also per gallon:

Solvent.	Cost per Pound.	Cost per Gallon.
Commercial chloroform	$ .25	$3.10
Carbon tetrachloride	.08	1.08
Sulphuric ether	.32	1.93
Carbon disulphide	.04	2.42
Gasoline	.024	.14
Benzol	.034	.25

Chloroform and carbon tetrachloride are non-combustible under ordinary circumstances. Carbon disulphide ignites below a red heat. Gasoline is not ignited excepting by the naked flame and with electricity. For practical purposes on a large scale, naphtha is very generally used. The table readily shows this solvent to be relatively inexpensive.

Below we have tabulated some of the physical properties of these solvents:

Solvents.	Density.	Boils at Degrees Cent.	Boils at Degrees F.
Ether	.73	34-36	07.20
Carbon disulphide	1.27	46-47	114.80
Chloroform	1.49	60-62	140
Gasoline	.71	50-70	130-167
Carbon tetrachloride	1.63	77	170
Benzol	.88	80.5	177

To any one unacquainted with the solvent action of these materials, the amount of fat capable of being

absorbed is surprising. As an example of cheap fats which are in large number of instances thrown away, we have selected wool and garbage grease, both of which are now extracted in large quantities Wool grease finds a market at $.0225 per pound and garbage grease brings about $.04 per pound. These are sold in tank car lots.

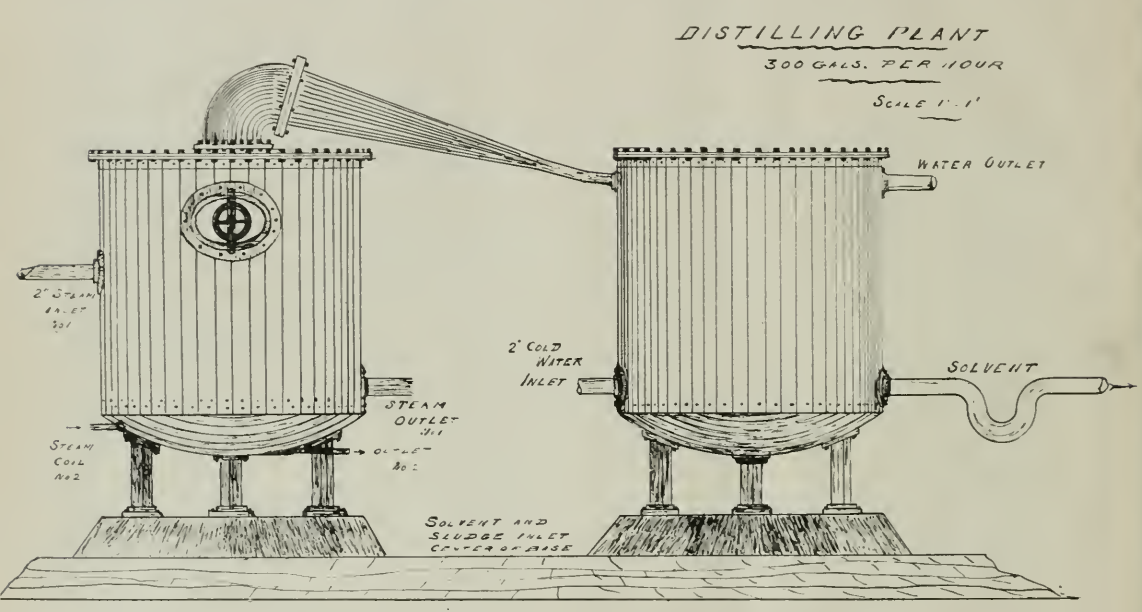
The following is a table showing the percentage of grease dissolved by the above solvents:

Solvent used.	Grease used.	Density of solution.	Percentage of grease dissolved.
Chloroform	Garbage G.	1.109	36.27%
Chloroform	Degras	1.211	31.76
Carbon tetra.	Garbage G.	1.190	44.18
Carbon tetra.	Degras	1.303	33.34
Ether	Garbage G.	.847	49.00
Ether	Degras	.832	43.00
Carbon disulphhide	Garbage G.	1.090	43.60
Carbon disulphide	Degras	1.1480	33.50
Gasoline	Garbage G.	.832	35.70
Gasoline	Degras	.795	32.60
Kerosene	Garbage G.	.8465	44.09
Kerosene	Degras	.8461	38.13
Benzol	Garbage G.	.898	54.32
Benzol	Degras	.876	47.56

After having consulted the above tables, the cheapest low boiling point solvent is found to be gasoline or naphtha. We have purchased samples in the open market and present a curve showing the percentage distilled at different temperatures and at different steam pressures. This table contains a belt within which grease is readily extracted and recovered from many substances including wool (grease), dry garbage and leather.

For practical purposes, ordinary steel construction is satisfactory for building extracting machinery and a heating coil made of a good quality of iron will withstand the corrosive action of the fats extracted. Our own experience in this particular covers a period of two years with a machine in constant use.

One of the simplest and most efficient forms of extractor consists of a closed cylindrical container within which the material to be extracted is placed, usually through a large man-hole in the top. Suitable metal strainers are provided to prevent the naphtha exits from choking. We have not been able to extract grease from leather or dry garbage simply with the naphtha vapor. The cold or slightly warmed solvent is introduced in such quantity as to completely envelop the mass. The solvent flows into the apparatus either by gravity supply or is pumped in with a metal ring pump. A steam coil is sometimes used to increase the extractive quality of the solvent. When the process is complete, the liquid is run off into a distilling apparatus where the grease is separated. The naphtha is evaporated and passed through cooling coils while the grease flows downward into large tanks. Very interesting apparatus has been developed to effect complete evaporation and separation. When the product is ready for market, the storage tank is warmed by steam coils, air is admitted



Still for Recovering Solvent.

through the top of the tank while the grease is forced out through the bottom into tank cars.

The naphtha extraction is made more complete by introducing live steam and separating the resulting naphtha and water at their density line, a point which is easily determined through a glass gauge at the side of the apparatus. Small pieces of white paper dipped into, the naphtha and dried almost immediately prove the presence or absence of grease. By this process, from 80 per cent to 90 per cent of the fat in low grade materials can be cheaply recovered. This applies to fish waste, slaughter house sweepings, garbage and tankage. The material to be extracted must not contain more than 2 per cent or three per cent of moisture, otherwise the solvent action is superficial. When steam is added to drive off residual naphtha, the solid matter adds about 10 per cent of water which must be again dried out.

We have made tests to determine the percentage of grease entrained by naphtha when the mixture has been distilled. The apparatus employed had but recently been installed. The distilling and cooling tanks were each five feet in diameter and five feet in height. The heating coil was two inches in diameter and supplied by steam at 60 pounds pressure. Six and one-half barrels of naphtha were distilled per hour. This was examined for its grease content. The grease found parts per million of naphtha distilled were as follows:

First barrel	.560
Second barrel	.044
Third barrel	.055
Fourth barrel	.016

The result obtained in the first instance was attributed to grease in the new coil. Other tests have been made which prove that naphtha can be distilled from grease without entrainment. In the foregoing instance, the residue in the distilling apparatus was analyzed and found to contain:

	Per cent.
Heavy grease	29
High boiling naphtha	6
Water	65

When water is present in the still, a small percentage of it passes over but separates after an hour or more.

A fat extraction plant is a very dangerous piece of apparatus unless handled with extreme caution. All closed containers should be provided with safety valves or plugs to prevent explosion from pressure. Smoking should be absolutely prohibited even in the region of the plant. Electric lights should be used only.

We have made experiments with fibre carrying 10 per cent mineral oil none of which could be extracted with extreme pressure but nearly all of which was recovered with naphtha. Dry grape seeds would yield but a fraction of one per cent of oil when heated and pressed. From these naphtha extracted 10 per cent of an edible oil.

We call the attention of the members of the Institute to the extraction of low priced oils and greases becauses we believe that these represent an actual national asset. Enough garbage is collected in every large city of the U. S. to average from three-fourths to one pound to each person. This contains about 4 per cent fat, more than 3 per cent of which can be extracted and marketed. The residual mass is worth from $7.00 to $10.00 per ton as fertilizer. In the city of Cleveland, O., these materials are extracted at a profit, paying for the collection throughout the city.

The fuel value of grease is not greater than $5.00 per ton, while its market value when extracted for soap and lubrication is from $60.00 to $80.00.

In a well organized plant, the naphtha loss is 16 gal. per ton of grease extracted, costing about $4.00.

The U. S. Civil Service Commission, Washington, D. C., will hold an examination on April 20, 1910, at various cities throughout the country, to secure eligibles from which to make certification to fill such vacancies as may arise during the year in the position of laboratory assistant (in chemistry) and assistant chemist in the Bureau of Standards, Department of Commerce and Labor, at salaries varying from $900 to $1,200 per annum for laboratory assistant and from $1,400 to $1,800 per annum for assistant chemist. The advanced places are designed for those who have done considerable graduate work or attain exceptional grades, or show special skill in research. The duties in connection with these positions vary from routine testing to advanced work involving original investigations. As far as practicable, appointees are assigned to work in the subjects for which they are best fitted.

The examination will consist of the subjects mentioned below, weighted as indicated:

Subjects	Weights.
1. General physics	15
2. General chemistry	35
3. Education and experience (rated on application)	50
Total	100

Applicants must show in their applications that they have been graduated or that they are about to be graduated from colleges or technical schools, or that they have attained an equivalent education or training. Experience has shown that only those who have had the equivalent of at least four years of thorough chemical training in a college of the better grade are able to pass the examination creditably, if at all. The exacting nature of the work demands assistants of considerably higher than average grade. Training or experience in drug or food chemistry, agricultural chemistry, medical or biological chemistry, has practically no bearing on the work of the Bureau and will receive no credit in rating on that account.

THE PREPARATION OF BARITE FOR THE MARKET.*

By A. A. STEEL.

Professor of Mining, University of Arkansas.

Previous to 1905 most of the barite of Missouri was prepared in the mill of Nulsen, Klein & Knausse, and some by J. C. Fink Mineral & Milling Co., both of St. Louis. The former has a department for making floated barite, resembling that of the new mill at Mineral Point, but a second-grade pigment is also made from unbleached selected barite. These mills are not in Washington county, and it seems better to omit a discussion of them, since they are similar to the many other mills which have been previously described.

During 1904 the Point Mining & Milling Co. invested about $150,000 for barite-land and what is claimed to be the largest wet-process mill in the United States. Its capacity is about 35 tons of finished product per 24 hours, or, allowing for delays, about 10,000 tons per year. The mill was designed by W. R. Macklind, who has kindly given me the following data:

A diagram of the operations at this mill is given in Fig. 1.

The barite is weighed upon a platform-scale and shoveled into the ore-house, which has a horizontal air-drill with chisel point for cleaning the flint and iron from the barite when this is not done by the miners.

From the ore-house the barite is shoveled into an 11x16 in. Blake breaker below the floor, which reduces it to pieces of 1-in. size. It is then elevated to a 30-ton bin at the top of the room, whence it is taken to three modified log-washers in series, in which nearly all of the clay is removed.

The washed barite is wheeled across the floor to two Macklind "slip" mills or modified arrastres, through which a large stream of water flows, and floats the fine barite over the edge of the pan. This milky water is raised to the top of the mill by a 4-in. centrifugal pump, and fed through a small screen into 12 iron spitskasten 4 by 4 ft. in since. The over-

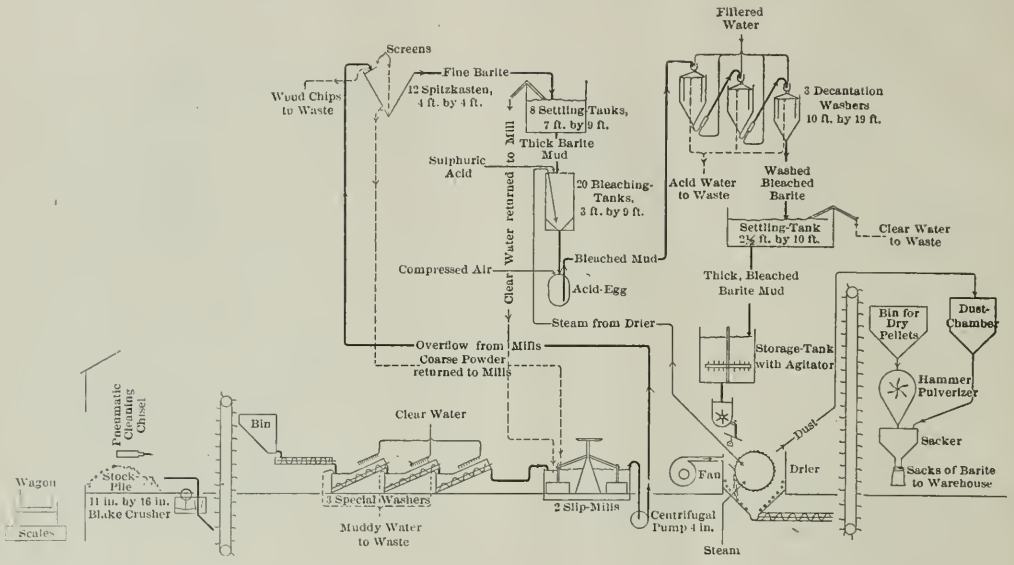


Fig. 1—Diagram Showing the Preparation of Barite in the Mill of the Point Mining & Milling Co., Mineral Point, Mo.

size is drawn off through spigots at the bottom of each box and returned to the slip-mills. The fine barite overflows opposite the entering stream into one of 8 settling-tanks, 7 by 9 ft. in size. The clear water is siphoned from these tanks and returned to the slip-mill. The thick cream-colored barite mud, which contains but 25 per cent of water, is drawn off through 4-in. plug-valves and a rubber hose to one of 20 bleaching-tanks on the floor below.

The required amount of 66 per cent sulphuric acid is added, and the mass agitated and kept at the boiling-point by a jet of steam introduced through a lead pipe. When the barite becomes white it is drawn off through a plug-valve in the bottom, and raised by an acid-egg to the first of three Macklind continuous decantation-washers, Fig. 2, in which nearly all of the free acid is removed. From the bottom of the last washer the barite is drawn off to one of two settling-tanks, 2.5 ft. deep and 10 ft. in diameter. Here as

*Part of a paper published by permission of the Director of the U. S. Geological Survey in the *Bulletin of the American Institute of Mining Engineers* for February, 1910.

much clear water as possible is siphoned off, and the barite let down into a storage-tank provided with an agitator to keep the barite moblie, since it contains but 15 per cent of water.

From the storage-tank the barite flows to a Macklind continuous automatic drier. A screw-conveyor collects the pellets of barite below the drier and delivers them to a belt-elevator supplying a bin above a Williams hammer-mill which pulverizes these pellets. The product is packed in 100-lb. duck sacks, and stored in a warehouse of 3,000 tons capacity.

The mill is driven by an 18 by 36-in. 200 h.p. Fulton-Corliss engine, running at 75 rev. per min., and supplied with steam at 100 lbs. per sq. in. pressure, by two 72-in. by 18-ft. return tubular boilers. There are a feed-water heater, duplicate feed-pumps, etc. A 35-kw. direct-connected Westinghouse unit supplies current for lighting the mill, and a Curtiss belt-driven compressor supplies the compressed air.

Besides the superintendent and office man, there are 12 laborers at $1.50 a day on the two shifts, two slip-mill men at $2, one bleacher at $2, two engineers at $2.50, and two firemen at $1.75, all working 12-hr. shifts. At the time of my visit the mill had not been operated long enough to get reliable data of costs, and details of operation were being constantly improved. The cost of manufacture is somewhat high.

Much of the machinery is standard and need not be described. Each unit of the washer consists of a 12-in. screw-conveyor, 10 ft. long, inclined at an angle of 20 degrees. The housing of the conveyor is arranged to hold the water level high enough to cover two-thirds of the length of the screw. Above this the barite, while being stirred by the screw, is sprayed with about 25 jets of water, ⅛-in. in size, under a 45-ft. head. The edge of the screw-conveyor has a V-shaped notch, 1.5 in. deep, every 5 in., which allows a larger part of the fine material containing the most clay to flow back again and be rewashed. At the lower end of the conveyor a strong jet of water washes the mud and a little of the finest barite over the edge of the housing. The barite is fed upon the lower end of the first conveyor and discharged from the top of the last one. These washers have a capacity of about 120 tons of barite in 24 hrs., and consequently are not operated continuously. Each unit requires about 40 gal. of water per minute.

The slip-mills were designed and patented by Mr. Macklind. Briefly, each mill consists of a tub of steel, 10 ft. in diameter and 3 ft. high, which is paved with carefully-cut blocks of Missouri granite. Over this pavement are dragged four granite blocks, roughly triangular, 36 in. on a side and 18 in. thick when new. There is a 3-in. bevel on the bottom along each edge. Heavy three-armed cap is clamped to the top. This cap has four holes about 6 in. apart along the leading side, and the dragging arm is frequently changed from one to the other of these to change the direction of the drag and prevent corrugation in the bottom of the stone. Once in about 60 days the cap is loosened and the stone turned to present another leading-edge, which makes it wear evenly. At such times the bottom of the stone is usually roughened slightly. The stone should last for three years, but the wear on the bottom of the mill is about twice as rapid, and is, of course, greatest at the periphery. About once in two years the bottom will have to be raised or renewed.

Among the new features of this mill are an unusually heavy spider, and an arrangement of a weight and lever like a safety-valve by which any fraction of the weight of the spider can be transferred to the stones. This is adjusted to suit the different grades

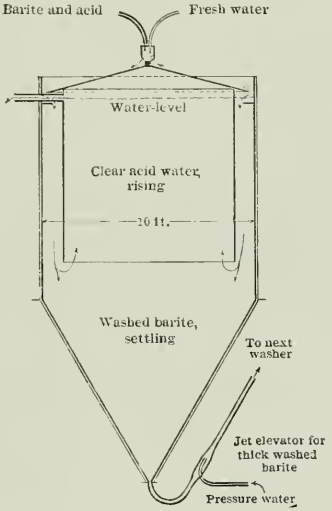


Fig. 2—Macklina Coninuous Barite Washer.

of barite. The weight-pin can also be lengthened to allow for the wear of the stone. The rest of the weight of the spider is carried upon a ball-bearing toe-piece raised above the water.

In the old-style mills trouble was caused by the tendency of the charge to form a self-supporting ring between the stones, which would then rub upon the bottom and wear more rapidly, and even at times break the gear or spider on account of the rapidly-increasing load. In this case the mill had to be stopped and the ring laboriously broken by hand. Mr. Macklind corrected this difficulty by providing the main-shaft with a ball-bearing collar, which can be raised 6 in. by a steam or compressed-air piston. This also raises the stones, and the water soon causes the ring to collapse. It seems that this difficulty would be avoided if the distance between the stones were made greater by decreasing their number or increasing the diameter of the mills, according to the Mexican style. Mr. Macklind's scheme, however, has the incidental advantage that when the stones are raised the spider can be easily revolved by hand for inspection

or repairs or for cleaning out the mill. In starting up it can also be brought to its normal speed of 20 rev. per min. by hand, so a simple positive clutch can be used on the gear.

When the mill is grinding properly, the stones tremble or chatter noticeably and the gearing runs without noise. When one of the stones begins to rub on the bottom the groaning of the gear should be immediately noticed by the attendant, who then raises the spider for a moment. The mills should have about 8 in. of barite in the bottom, and the attendant sounds them with a rod to determine the need of more feed, but of course soon learns how rapidly to shovel the barite. At 20 rev. per min. each mill has a capacity of from 15 to 18 tons per 24 hrs., but generally 12 or 13 tons is ground, and this output determines the capacity of the entire plant. About 15 h.p. is required for each mill.

The water flows through this mill at a rate of 100,000 gal. per 24 hrs. This large stream of water may be necessary to provide for an increase in the capacity of the mill, but since more than 40 h.p. is required to raise the water 45 ft. to the separating-tanks, it does not seem to be as economical as increasing the number of mills. The number of spitzkasten was increased in order that the floated barite should be fine enough. It is said that this fine barite was examined with a microscope, and the largest pieces were small enough to go through a 300-mesh sieve. The stream is divided equally among all the boxes, and enters through a fine screen to reduce the agitation. This screen also removes a few small pellets of clay and chips of wood. There is also a vertical screen in the middle of the box to prevent the formation of eddies.

The bleaching-tanks are lined with three lengths of 36-in. sewer-pipe without bells, and four special tiles form a coneshaped bottom. They are made water-proof by an 8-lb. hard-lead covering on the outside. The hydrostatic pressure is resisted by oak staves and iron hoops outside the lead. The tanks are charged with 2 tons of settled barite, containing 25 per cent of water, and a minimum of 240 lb. of 66 per cent sulphuric acid is added. The acid is received in tank cars and costs a cent a pound. It is run into a large steel storage-tank, from which it is pumped by an acid-egg to an elevated leadlined tank; thence it flows through lead pipes and valves to the bleaching-room on a level with the top of the bleaching tanks. Here it is handled and measured in a small lead-lined tank-car. After the acid is added, steam is run into the bottom of the tank to agitate the mass and heat it to nearly the boiling point. At first, lead-lined iron agitators were used, but they wore out very rapidly. The tile lining of the tanks protects the lead from all mechanical wear, and it soon becomes coated with lead sulphate.

It requires about 45 min. to heat the mixture, and the best quality of ore can be bleached in from 6 to 7 hrs.; but since there is plenty of tank-capacity, the bleaching is always continued 12 hrs. or more. If the bleaching is not finished in 12 hr., more acid is added; but it is unsafe to reduce the amount below 120 lbs. per ton, on account of uncertainties as to the ore. No attempt is made to save the unused acid. To tell when the bleaching is complete, a 2-oz. bottle, full of barite, is compared as to color with a standard sample.

The bleached barite is drawn off through lead-covered plug-valves in the bottom. The handling of this hot, thick, heavy, and corrosive material has proved very troublesome. It has been most successfully pumped to the washing-tanks by a very heavy acid-egg.

These washers, designed by Mr. Macklind, consists of lead-lined iron tanks, 10 ft. in diameter, 19 ft. high, having a cone-shaped bottom. In a lead cup above the center of the tank the bleached mud is mixed with a strong jet of water, and then distributed by a flat lead cone to the circumference of the tank and discharged upon baffle-plates. In the center of the tank is a bottomless lead cylinder, 8 by 8 ft., inside of which the water rises so slowly that all the barite settles out, and only clear acid water is discharged to waste through a lead pipe at the surface.

From the bottom of the first washer the barite passes to a similar one 3 ft. lower. From this it goes to a third one still lower. Since, with this head, the heavy, settled barite would not flow from the bottom of one tank to the top of the next, the current is maintained by a strong jet of wash-water directed upwards in the discharge pipe. (A similar arrangement might be serviceable in elevating the thick barite from the bleaching-tanks.)

All the acid should not be removed or the barite will immediately turn a light yellow; the end-point used to be determined by a slight acid taste, but the washing is now continued until there is no taste, but the iron sulphate remaining in solution will give a slight blue color with potassium ferrocyanide, thrown upon the last spreading-cone. When this does not show, the quantity of wash-water is reduced. The reason for the change of color when no acid is present is not understood. This acid prevents the use of floated barite for weighting rubber and paper, but for paint it is not objectionable. If the settled barite mud at the bottom of the washer has 50 per cent of water, this leaves about ⅛-lb. of acid to the ton of barite; if it has 100 per cent which is more likely, 1 lb. to the ton will be left.

The wash-water is filtered through six sand-filters, 36 by 60 in. and is obtained from a small creek by a separate pump. The general mill-supply is filtered only when very muddy.

The essential part of the Macklind drier is a cylinder of wrought-iron pipe, 36 in. in diameter and 8 ft. long, revolving one-and-a-half times per minute, and heated inside by live steam. Upon this cylinder the barite is dropped by a plate shaken 200 times per

minute by a cam. The thick, settled barite mud is fed upon the shaker-plate in fine streams 4 in. apart through pin-valves from the feed-trough, which contains an agitator to prevent packing. The drops of barite falling upon the hot drum are soon dried and are scraped off by a plate after nearly a full revolution. This scraper leaves a thin layer of strongly-adhering barite, which prevents discoloration from the iron. The live steam enters through a stuffing-box at one end, and the condensed water is drawn off through a siphon-pipe in the other trunnion and circulates through coils along the side of the housing, and dries whatever barite is spattered off by the boiling pellets.

To prevent the accumulation of air in the cylinder, some steam is drawn off through a straight pipe entering through the siphon and carried to the bleaching-tanks.

The finished barite is tested for color by putting a spatula-full upon a glass plate beside a standard sample, smoothing it down beneath a piece of paper, and comparing as to color. It is then moistened with turpentine and again compared. In this way it shows as white as a standard sample of white-lead, which had a slight buff color, but not as white as good zinc oxide, which is blue in comparison. The product is tested for grit by rubbing it with a spatula upon soft glazed paper, which should not be scratched. Barite which contains flint will be apt to show more grit when floated, since the equal-falling grain of quartz is so much larger than the heavy barite. Barite ground between burr-stones gets grit from the mills. In the wet-process mill, in which the barite is ground before bleaching hard iron or steel could be used in the mill and the pigment would be entirely free from grit if the barite contained no quartz.

Barite, on account of its prismatic cleavage, forms a "sliver" pigment rather than a granular one. These slivers mat together in the paint, and since barite is slightly harder than the other pigments, it forms a more durable paint. It is also entirely unaffected by weather, and does not dissolve like zinc, or blacken with sulphur like lead.

White-lead is said to saponify linseed oil. At any rate, after a few years, a pure white-lead paint will chalk and rub off, leaving the surface in good shape for a second painting. So far as known, zinc is not used alone, but if the paint contains too much barite, it peels off and a second coat of paint will not stick. The mixture of white-lead and barite pigments is therefore better than either one alone. Some of the peeling may be due to inferior oil.

When barite is sufficiently ground it will spread well. The chief objection to it is its translucency and lack of covering power. This deficiency is best corrected by zinc oxide, which has the greatest covering-power. Some of the paint-men therefor say that an equal proportion of the three pigments makes the best paint. The unfortunate feature is that usually good barite costs less than a cent a pound, while the other pigments cost 6 or 7 cents, so that much of the prepared paints contain too great a proportion of barite, up to 60 per cent.

Very little barite is now used in making fine book-paper, since the weight of a book is no longer considered an advantage, and fibrous talc is used instead. Its use in rubber goods seems to be a trade secret.

For making barium salts a very inferior barite can be used, but most of this chemical manufacturing work is done in Europe. There would be a big demand for barium oxide for treating boiler-water containing much calcium and magnesium sulphates, but it is not yet supplied cheaply enough in the United States.

I desire to express my cordial thanks for information regarding Washington county barite to W. R. Macklind, of Mineral Point; James Long and James W. Richeson, of Potosi; Frank Long of Cadet; and Robert McClay, of Bliss, Mo.

At the October 1909, Convention of the American Railway Bridge and Building Association the following facts were brought out on the subject of wood for piling. Mr. W. T. Powell, Colorado & Southern Ry., Denver, Colo., reported that untreated long leaf yellow pine had a life of about six years and the use of this material was abandoned in favor of oak about two years ago. The oak procurable by his road is small and crooked so the use of treated short leaf yellow pine will be resorted to although the life of good oak piles is placed at approximately sixteen years. Mr. J. T. Parker, Santa Fe Coast Lines, San Bernardino, Cal., stated that his lines use mainly Oregon pine for piles but in recent years this is inferior in quality to that received ten to fifteen year ago. White cedar has given the best service, lasting from eight to fifteen years, depending upon soil and other conditions. Second cuts do not last so long. Good Oregon pine has given nearly the same length of service under like condition. Mr. L. D. Smith, Southern Pacific Co., San Francisco, reported the use of Oregon pine and Washington fir treated with ten pounds of creosote per cubic foot at the company's plant. In Texas on the El Paso & Northeastern R. R., Mr. B. J. Mustin, said Texas pine creosoted is used in all pile bridge-work. Mr. A. H. King, Oregon Short Line R. R., reports success with saltwater, the piles of Oregon fir being submerged a year or longer in the waters of the Great Sale Lake. As long as the saline coating remains on the timber the crust proves a very valuable preservative, and piles driven 25 to 30 years ago in the lake are in perfect condition, but as yet he is unable to say what the results may be with piles thus treated, and used in other places, remote from the lake.

THERMOMETRIC STANDARDS.

By ROBERT E. BRADLEY.

Thermometers are usually calibrated for accurate work by determining their indications in steam at atmospheric pressure, and in a mixture of ice and water, and then plotting the diameter of the bore by reading the lengths of a short thread in different parts of the tube. These operations, to attain any very great precision, require not only minute attention to detail, but also a large amount of experience, on account of the numerous places where errors may be made. There is an error in adjusting the height of the mercury in the barometer, which error reflects directly on the operation because it is used to ascertain the temperature of the steam; there is a slight error in the uncertainty of the exactness of the formula for stem correction. If this is omitted there will be an error because of the great difficulty in getting all of the stem at the same temperature at the bulb. There is an error in determining the zero-point because of the uncertainties of the lag-ice reading, and also of the various kinds of glass used.

The direct comparison of the scale with that of an accurate mercury thermometer, or with a standard gas thermometer, where both are immersed in a liquid bath, will give the desired comparison. The objections to the former are on account of its cost when used by individual students, and to the latter on account of its unwieldiness and inaccuracy in inexperienced hands.

What is most to be desired is a simple device of some sort, which, when placed in a liquid bath with the thermometer to be tested, will indicate certain particular points of temperature by a sharp, definite change, and which will not be disturbed by outside influences, such as atmospheric pressure. The following device fulfills these conditions.

Convenient volumes of amyl and ethyl alcohols are mixed together and brought to a certain definite temperature. This temperature must be *exactly* known. Distilled water at the same temperature is then added drop by drop, until a slight turbidity still persists after shaking. The liquid is then quickly transferred to a tube and sealed to prevent any change in its composition by evaporation. At any temperature above that at which it was prepared this tube will be perfectly clear, and filled with a homogenous liquid. The slightest drop *below* this temperature will cause the amyl alcohol and dilute ethyl alcohol to separate into minute drops, causing a distinct milky appearance. Further drop in temperature will cause it to settle into two distinct layers.

In the same way, by bringing water to a certain definite temperature and adding coniine—an alkaloid extracted from the seeds of the spotted hemlock—until a slight turbidity persist after shaking, and sealing in a glass tube as before, a device is obtained which will turn milky at the least rise in temperature *above* that at which it was prepared, because coniine is one of the few substances that is less soluble in hot than in cold water.

Three of these tubes, indicating for example 3°, 50°, and 95°, will serve as an absolutely unchangeable standard of reference.

The following statistics covering the exports of crude rubber from Brazil during the past year are taken from a recent consular report. Prices of rubber during 1909 ruled very high, and exchange was very steady, notwithstanding which the percentage of increase has not been as great as was to be expected, and it would seem that the high prices at present ruling have had very little effect on stimulating an increased output. The year 1907 was, as regards prices, a very bad year, yet the percentage of increase was much greater than in the better year, 1909. But for the low waters in the upper rivers we would have had more rubber, but even had the percentage of increase been as high as for 1907 there would still be left something to explain. The following statement shows the exports of rubber from Para, Manaos, Iquitos (in transit), and Itacoatiara during the calendar year 1909, in kilos of 2.2 pounds:

Class.	United States.	Europe.	Total.
Fine	4,493,610	9,817,431	19,311,041
Medium	1,790,866	1,927,065	3,717,931
Coarse	5,878,250	2,968,896	8,847,155
Caucho	2,678,643	5,116,318	7,789,961
Total	19,841,378	19,829,710	39,671,088
Exported from—			
Para	9,655,053	9,627,831	19,327,884
Manaos	10,068,945	7,356,417	17,425,362
Iquitos (in transit)	105,693	2,650,841	2,756,534
Itacoatiara	11,687	149,621	161,308
Total	19,841,378	19,829,710	39,671,088

The total exports of crude rubber from Para, Manaos, Iquitos, and Itacoatiara during the four years preceding 1909 were as follows, in kilos: 1908, 37,685,487; 1907, 37,514,152; 1906, 34,767,755; 1905, 33,916,888.

A national convention of inventors is to be held at Rochester, N. Y., June 13 to 18, 1910, under the auspices of the International Congress of Inventors, an organization established four years ago to work for the reform of patent law and procedure and the better protection of inventors' rights. Arrangements for the convention are in the hands of Alexander B. Lamberton, president of the Board of Park Commissioners of Rochester.

THE PLANT.

PRODUCER GASFIRED LIME PLANTS.*

By E. SCHMATOLLA.

Chemical Engineer, New York.

I started to build and operate Producer gasfired shaft kilns for burning lime, dolomite, magnesite and similar rock products in the year 1896 in Berlin. I frankly admit that I was not the first who tried to burn lime with producer gas. As far as I know, the first producer gasfired lime kiln was built in Bohemia in the year 1864. Other producer gasfired kilns were built later, but I very often heard in the lime plants that producer gasfiring has been a failure.

However, from my former experience in steel works and metallurgical plants, where producer gasfiring was already highly developed, I was convinced that producer gasfiring could be correctly adapted to lime burning, and that it would govern the future also in the lime industry. It has taken me years of hard work to get a few gas kilns built in Germany and other countries of Europe, and to overcome little by little the great prejudices which I found firmly established among the lime burners. About the year 1906, I had already erected and reconstructed more than thirty of such kilns.

Everyone here is familiar with the photographs of the plants which have been described in detail in my several pamphlets, and a copy of which I will be glad to furnish any who may ask for them. My work in this line has been signally successful and entirely satisfactory to the owners of the several plants, for the reason that gasfiring has introduced economics which have amounted to a profit in every case.

In the year 1908 the leading German journal wrote about the Schmatolla gasfired lime kiln as follows:

"Attempts have been made for many years past to burn lime with the aid of producer gas instead of solid fuel, but progress has always been very slow, and it is only during the last few years that the matter has been more carefully studied and made a commercial success.

"Among the kiln builders who have been chiefly responsible for the progress of the lime-burning industry, no one has been more successful than Mr. Ernst Schmatolla, whose work has succeeded beyond all expectations in the adaptation and construction of gas producers and kilns for the lime-burning industry. Quite recently we examined one of these kilns in Mr. Franz Oertel's lime works in Zossen, and saw it in regular work. The gas produced is passed into three vertical flues, each of which is connected with two openings leading to the inside of the kiln, this arrangement securing an even distribution of the gas through the kiln. The air necessary for the combustion of the gas is admitted through regulated openings in the three doors of the kiln from which the burnt lime is removed. This passing through the finished lime becomes heated and ignites the gas with great readiness. A supply of air is also admitted between the lining and outer wall of the kiln, where it also becomes heated and enters the kiln nearer the top. This secondary air supply assists in keeping the lining cool and increases its durability, but its main purpose is to finish the combustion by igniting any small quantity of gas previously remaining unburned. The temperature of the kiln was even throughout, and can be regulated in all the different parts with accuracy. The lime produced was completely burned, and in large lumps, a very small proportion of "smalls" being formed. The latter was removed through a separate opening, and thus automatically separated from the lumps. The kiln has a daily output of 15 tons, and a weekly output of 107 tons is a fair average of many weeks' working. The analysis of the waste gases is interesting. The sample was taken from the feed opening and consisted of:

Carbon dioxide	34.5 per cent
Carbon monoxide	0.6 per cent
Oxygen	0.4 per cent
Nitrogen	64.5 per cent

"This analysis shows that the combustion in this Schmatolla gas kiln is remarkably complete, and that the firing is carried out with a very small excess of air. This last is of great importance in preventing a waste of fuel.

"This particular kiln has been in regular use now for more than three years with perfect satisfaction to its owners, and it is quite clear that the problem of economical firing of lime kilns has been solved by Mr. Schmatolla."

Of course I also had to get experience and to improve the design from year to year. You know probably that high-grade coal is very scarce and expensive in many countries of Europe, and that they are compelled to use low-grade fuels, as, for example, peat, lignite, and brown-coal, which are all very different from each other and very in the different deposits. Therefore, I had to adapt the kiln and to instruct the

*Based on a lecture delivered before the National Lime Manufacturers' Association, in Pittsburg, Jan. 29, 1910.

operators not only with regard to a different quality for a limestone, but also to a different sort of fuel, and this made the work very difficult and the progress very slow.

When I started in Germany to introduce the gas kiln, the straight fired shaft kilns, as generally used in America, were in use in many of the works of Europe. Then there was the Hoffmann kiln which is economical in fuel consumption, but expensive in labor. The latter is the reason that the Hoffmann kiln has not been tried in this country. The Hoffmann kiln is also very expensive to build, and big capital is invested in Germany in such kilns. This system is quite different from the shaft kiln. In this country the lime industry is used to burn in shaft-kilns, and it makes no great difference to go over to the gas system, as the kilns can easily be reconstructed or altered. This is the main reason why the producer gasfired shaft kiln will soon be generally used, replacing the old or present system in America.

REASONS OF FORMER FAILURES.

In many cases small shaft kilns have been fitted with too large and too many producers, and the reason of the failure was that the fire in the kiln was killed by an excess of gas, which did not allow a sufficient quantity of air to enter the combustion chamber. In other cases there was too much draft, and the fire overheated and melted the lining, but did not reach the center of the shaft.

The product was half overburnt material mixed with core and a consequent waste of fuel. In many cases the producers, the gasmains and the kilns were so arranged that the gas started to burn inside the producer and in the gasflues, losing the greater part of its efficiency before it reached the lime. The greatest trouble, which has caused many failures and which I had to overcome myself, and for which I at first was not prepared, was caused by soot filling the gasmains and gasflues, thus preventing a clear passage and equal distribution of the gas. The producer gas fired kilns that are working in this country, so far as I can ascertain, are operated in a similar manner to direct fired shaft kilns. This means they are burning the producer gas inside the furnace with cold air which they draw from outside. With a good bituminous coal, containing much volatile matter (high-grade illuminating gas) they may get a pretty good result, but a good deal of the efficiency is lost in the furnace; and this is one of the reasons that the kilns have only a very small diameter and the economy is not very considerable.

CONCERNING DIFFERENT FUELS.

I can say from my experience that nearly all kinds of fuel may be used if the producers and the kilns are properly arranged for them.

Wood gives a very good gas, and it is very easy to gasify. Wooden slabs, shavings and similar waste of sawmills, which are very often destroyed in large quantities in refuse burners, are much better than the big pieces of wood, but sawdust requires a special producer with forced draft attachment.

Lignite and brown-coal vary widely in the different deposits, according to their age and other conditions, but if it looks similar to charred wood these fuels are mostly very easy to gasify without the use of forced draft, but sometimes the most experienced expert meets with unforeseen difficulties. There are some very good looking lignites, for example, in Texas, showing large lumps when they come from the mine which crumble into dust as soon as they get wet or heated, and such a fuel of course must be gasified by

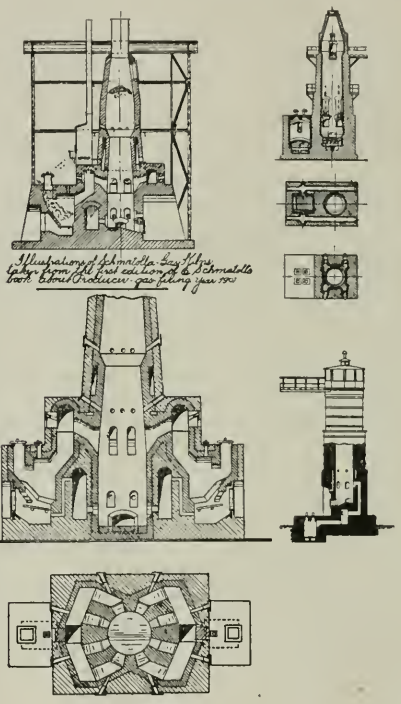


Fig. 1.

forced draft (but not by steam blowers), and the producers must be specially designed to meet the difficulties which are caused by such qualities.

Peat is very extensively used in Europe for producing gas and burning lime, but most varieties of peat contain much moisture and it is better to separate the gas from the water before it is introduced into the kiln.

Hard coal, anthracite and coke, can be gasified in lumps by natural draft, but when they contain much dust or fine stuff the air must be blown through the producer. With such fuel a great quantity of steam may be mixed with the air, and steamblowers may be preferably used.

Bituminous coal can be gasified also in the form of slack, or mixed with fine material, by natural draft,

as the fine material forms lumps inside the producer; but forced draft in most cases provides an increase in the output of the kilns.

I know that in America you like to build one large producer and feed a battery of kilns (each of which are comparatively small) from this one producer to save labor. But I prefer and would advise you to build larger kilns for large outputs, and medium sized producers that can be easily cleaned, close to the kiln, and so avoid long flues which mean a loss of heat and introduce soot troubles. One producer may be very properly arranged between two kilns.

To show you the development of my gas kiln I prepared a number of drawings, showing in Figs. 1, 2, 3 and 4.

Fig. 1 shows at the left side two illustrations taken from the first edition of my German book about "Gas-producers and Gasfiring," which was published in 1901, a few years after I had started to build gas kilns for lime burning. The upper figure shows a shaft kiln with one producer for lignite as fuel. The shaft has a similar shape to the kilns which are used in this country. The shaft is surrounded by a long gas main which is connected with the producer and with the shaft.

The lower figure shows a larger kiln with two producers in elevation and plan view.

The figure at the right side shows more modern types, designed a few years ago, and published in the new edition of my German books about gas producers and kilns, issued in 1908 and 1909.

The upper figure shows one shaft and one producer connected by straight gas mains, which can be easily cleaned and controlled from the outside. The producer is one for bituminous coal and uses natural draft.

The lower figure shows an older design where straight but longer gas mains are used, and the gas producer is arranged under the ground. I now prefer the upper arrangement, where the kiln and the producer stand on the same level, so as to have the gas outlets of the producer and the gas inlets of the kiln on the same level.

The kilns shown in Fig. 1 all correspond more particularly to the European conditions, where they still prefer kilns made of brick masonry.

Fig. 2 sheet is designed for and corresponds to American conditions, the outside brickwork being replaced by steel jackets or shells.

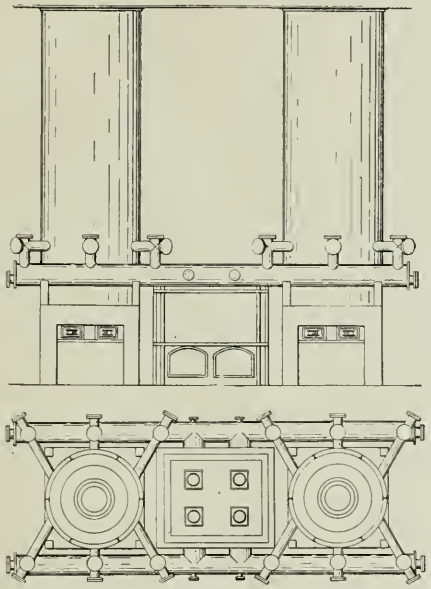


Fig. 2—Elevation and Cross Section.

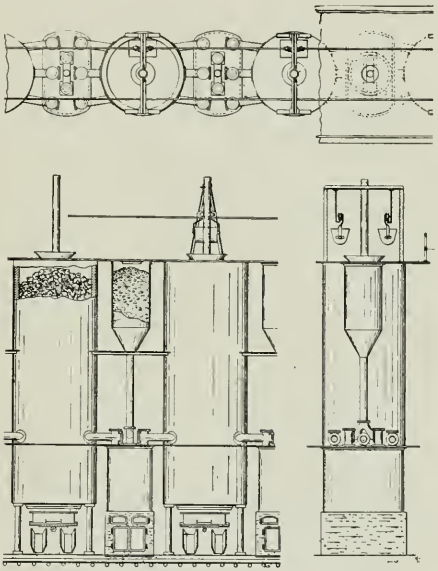


Fig. 3—Cross Section of Field and Elevation.

This drawing shows two kilns and one large producer arranged between the kilns and connected with the latter by two straight mains and short cross-pipes. This plant was designed for the Glencoe Lime & Cement Company, St. Louis, Mo.

Figure 3 is quite a new design, by which, after having studied the American conditions, I have tried to show how I would recommend to arrange a battery of lime kilns.

This design gives an elevation, seen from the front and from the side and a plan of the battery. The producers are arranged between the kilns, and all long flues are avoided. Each kiln with one producer is designed for an output of about 20 to 25 tons of burned lime per day, which gives medium sized kilns and medium sized producers. Above the producers coal hoppers are arranged between the kilns with one

chute for each producer, to avoid rehandling of the coal. For conveying the stone and the coal to top of the kiln a cable railway or some other conveying device may be arranged. In the middle of the battery, under the ground-floor, there is a conveyor belt upon which the burned lime, as it comes from the kiln in a perfectly cool condition, is dropping.

Figure 4 shows a plan view of a double kiln for an output of about fifty tons, with two producers, connected with the kiln by very short pipes, to avoid losses of heat, soot trouble, and to simplify the construction.

Producer gas fired kilns are not new in this country, but all that I have had the occasion to see, where working under conditions similar to the direct fired kiln, and the gas is burned in the furnaces before it

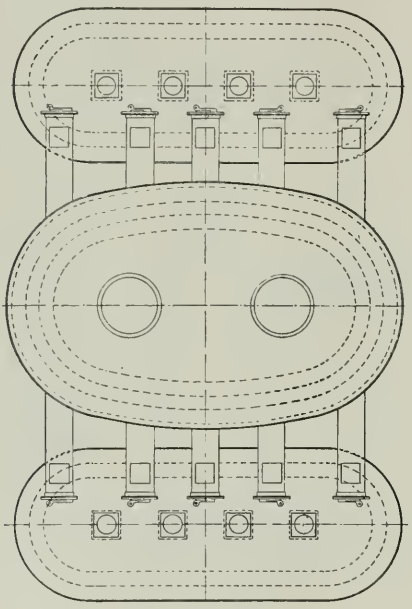


Fig. 4.

enters the shaft of the kiln. Therefore a part of the efficiency and length of the flame is lost, and the kilns have the same small diameter between the gas inlets as the direct coal fired furnace kilns—in most cases 6 feet or less, whilst a Schmatolla kiln, where the flame is developed inside the shaft, can have a diameter up to 9 feet between the gas inlets (or furnaces). The 6-feet diameter kiln, when cylindrical, has only an inside horizontal shaft area of about 27 square feet, whilst the 9-feet diameter shaft kiln has a useful shaft area of 60 feet, and the capacity is therefore more than double that of the small kiln. The larger the diameter between the opposite walls of the kiln, the smaller of course is the loss by radiation, and the cost of building the larger kiln more than *double* the output, are not twice as much as that of the small kiln, but only 33 to 50 per cent higher. I wish to explain further that the larger kiln does not require much more labor than the small kiln, and this makes a substantial economy of labor with the larger type. By giving the shaft of the gas kiln an oval shaped area the output of such a kiln may be increased up to fifty tons of burned lime per day.

As the heat which is accumulated in the burned lime is utilized in the cooler of the Schmatolla gas kiln, the lime is drawn from the kiln perfectly cool and can be shipped immediately without rehandling.

According to investigations made by the U. S. Geological Survey the total cost of fires in the United States in 1907 amounted to almost one-half the cost of new buildings constructed in the country for the year. The total cost of the fires, excluding that of forest fires and marine losses, but including excess cost of fire protection due to bad construction and excess premiums over insurance paid, amounted to over $456,485,000, a tax on the people exceeding the total value of the gold, silver, copper, and petroleum produced in the United States in that year. The cost of building construction in forty-nine leading cities of the United States reporting a total population of less than 18,000,000 amounted, in 1907, to $661,076,286, and the cost of building construction for the entire country in the same year is conservatively estimated at $1,000,000,000. Thus it will be seen that nearly one-half the value of all the new buildings constructed within one year is destroyed by fire. The total fire cost in this country is five times as much per capita as in any country of Europe. The first cost was greater than the value of the real property and improvements in any one of the following States: Maine, West Virginia, North Carolina, North Dakota, South Dakota, Alabama, Louisiana, Montana. The actual fire losses due to the destruction of buildings and their contents amounted to $215,084,709, a per capita loss for the United States of $2.51. The per capita losses in the cities of the six leading European countries amounted to but 33 cts. or about one-eighth of the per capita loss sustained in the United States. In addition to this waste of wealth and natural resources, 1,449 persons were killed and 5,654 were injured in fires.

The United States Steel Corporation has authorized the expenditure of $2,500,000 to increase the capacity of the Indiana plants of the Universal Portland Cement Co. This company in 1900 turned out only 32,443 bbls. of Portland cement; its output for 1909 was 5,786,000 bbls. and its estimated output for this year is 8,000,000 bbls. while additions to be made at Buffington and Pittsburg will bring the production for 1911 to 10,000,000 bbls.

According to a report from Consul Max J. Baehr, the shipments of Cuban sugar from the Cienfuegos district to the United States in 1909 were valued at $27,430,489.

THE LABORATORY

THE DETERMINATION OF THE PERCENTAGE OF PHOSPHOROUS RETAINED WITH THE FERRIC CHLORIDE IN THE ETHER SEPARATION.*

By R. J. WYSOR.

The use of ether as a medium for effecting the separation of iron from other metals in oxidized, hydrochloric acid solutions has long had practical application in analytical chemistry. J. W. Rothe in his original paper on this subject (Mittheilungen aus don Eöniglich Toch. Versuchsanstalten zu Berlin. 1892, Part III) discusses in detail his experiments, and the method by which the ether separation is accomplished. Carnot, in a later publication, ("Methodes d'Analyse des Fontes, des Fers, et des Aciers," 1895, p. 123, et seq.) pursues an investigation along the same general lines as Rothe, and adds one or two metals to the list of those which may be separated from the bulk of iron by the ether method. Recently, Andrew A. Blair has shown (Journal American Chemical Society, 1908, p. 1229) that molybdenum, in common with iron, exhibits an affinity for ether, and that a complete separation of this element may thus be effected from the other metals.

The writer has discovered no literature which treats of the behavior of phosphorus, or other nonmetallic elements, in company with iron in the other separation. In reviewing Rothe's article, the statement was found that no attempt had been made to determine whether ferric phosphate, or ferric sulphate could be separated from acid solutions.

It is the purpose of this paper to consider the behavior of relatively small amounts of phosphorus in the ether separation, under somewhat empirical conditions, in order that a certain critical value may be attached to the discussion. Conditions of experiment commonly occuring in practice were chosen, thus affording a commentary upon an existing application of the ether method, to which reference will subsequently be made.

In a number of preliminary experiments, a steel of very low phosphorus content was employed, together with a standard phosphorus solution, prepared by dissolving diammonium hydrogen phosphate in hydrochloric acid (1.13 sp. gr.). A sufficient volume of this solution to represent the amount of phosphorus desired, was added to one, two or three grams of the steel. A further addition of enough hydrochloric acid (1.13 sp. gr.) to make a total volume of 40 c.c. was then made, and after solution had been effected, the ether separation was made in the same manner as later described. Although interesting results were obtained, comparable with those secured in the ensuing work, their practical value was not evident, and the following materials were selected as the basis of experiment.

Two iron ores were chosen of the same soluble iron content, 57.5%, and of widely variant soluble phosphorus contents, 0.060% and 0.510%. These ores were mixed in such proportions as to represent approximately even gram weights of metallic iron, and definite weights of phosphorus as subsequently noted.

An iron ore of 68.6% soluble iron content and 0.055 soluble phosphorus content was used in conjunction with a standard phosphorus solution. This solution was prepared by dissolving diammonium hydrogen phosphate in dilute hydrochloric acid, and was carefully standardized so that each c.c. contained 0.0005 gram of phosphorus.

Several other iron ores were subjected to sufficient experiment, to indicate that approximately the same results were obtainable as those described in this paper.

METHOD OF PROCEDURE.

The requisite weight of the single ore, or of the two ores to represent one, two or three grams of metallic iron was employed. In the latter case, the respective ores were properly proportioned to yield 0.001, 0.002, 0.004, 0.008 or 0.016 gram of phosphorus as desired in the mixture. In the treatment of the single ore, the proper volume of the standard phosphorus solution was added, which together with the phosphorus content of the ore, would afford the desired weight of this element. All calculations were based on the soluble iron and phosphorus contents of the ores as previously mentioned. The numerical results obtained by these analogous procedures, appear in the appended tables in parallel columns.

The calculated weight of the single or mixed ores was digested in strong hydrochloric acid, with the aid of a gentle heat, for two hours, or until no further solvent action was apparent. The solution was diluted and filtered, the residue, after being washed free of iron discoloration, being discarded. If the standard phosphorus solution was to be added, the addition was made at this point, and the filtrate evaporated to dryness. The residue was dissolved in 40 cc. of hydrochloric acid (1.13 sp. gr.), gentle heat being applied to aid solution. The solution was cooled in water, and transferred to a single-chambered, cylindrical-

*Read at the December meeting of the Pittsburg Section, American Chemical Society.

shaped, separatory funnel, provided with a ground glass stopper, and having a capacity of about 175 cc.

Anhydrous ether (distilled over sodium) was used for all the separations, 40 cc. being employed for one gram of iron, 75 cc. for two grams and 100 cc. for three grams. Part of the measured amount of ether was used to rinse the dish, from which the solution had been transferred, the rinsings, with the remainder of the ether being transferred to the separatory funnel. After thorough agitation under cold, running water, the solutions were allowed to stand several minutes to permit as complete a separation as possible.

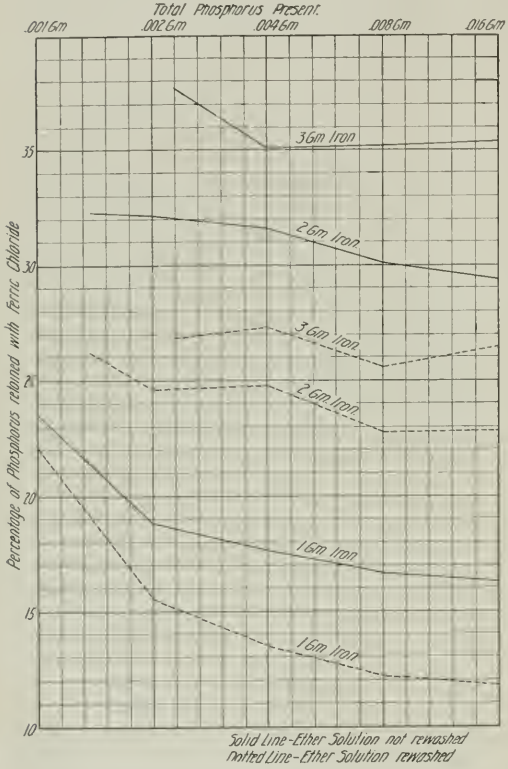


Diagram Showing Percentage of Phosphorus Retained in the Ether Solutions of Ferric Chloride.

The lower stratum was then carefully drawn off and discarded. The ethereal solution, containing the bulk of ferric chloride, if not subjected to further treatment, was washed with a sufficient quantity of water to remove all the iron and concomitant phosphorus.

A second series of determinations was made in the same manner as just described, except that after the lower, acid solution had been drawn off, the ether solution was rewashed with 10 cc. of ether saturated hydrochloric acid (1.13 sp. gr.). The solutions were again allowed to stand several minutes, the lower stratum was drawn off and discarded, and the ether solution washed with water as previously described.

The final solution, containing nearly all the iron, with the residual amount of phosphorus to be determined, was warmed to volatilize the remaining ether, then the excess hydrochloric acid expelled by evaporation. The determination of the phosphorus was completed by the well known gravimetric method, as described in the Methods of the United States Steel Corporation for the Commercial Sampling and Analysis of Iron Ores.

The interesting behavior of phosphorus under the varying conditions of experiment may readily be interpreted from the tabulated results, and the accompanying diagrammatic presentation.

TABLE I.

Percentage of Phosphorus Retained in the Ethereal Solutions of Iron.

Total Phosphorus Present.	Mixed Ores. Percentage of Total Phosphorus Retained with 1 gm. Iron.	Total Phosphorus Present.	Ore plus Standard Phosphorus Solution. Percentage of Total Phosphorus Retained with 1 gm. Iron.
0.00104 gm.	23.2	0.001 gm.	24.0
0.002 gm.	19.0	0.002 gm.	18.7
0.004 gm.	18.3	0.004 gm.	17.0
0.008 gm.	17.5	0.008 gm.	15.9
0.016 gm.	16.9	0.016 gm.	15.8
	2 gm. Iron.		2 gm. Iron.
.....	....	0.00146 gm.	32.3
0.00208 gm.	33.0	0.002 gm.	31.3
0.004 gm.	32.3	0.004 gm.	30.9
0.008 gm.	30.6	0.008 gm.	29.5
0.016 gm.	29.7	0.016 gm.	29.0
	3 gm. Iron.		3 gm. Iron.
.....	....	0.00219 gm.	37.7
0.004 gm.	35.2	0.004 gm.	35.1
0.008 gm.	34.8	0.008 gm.	35.5
0.016 gm.	35.4	0.016 gm.	35.9

From the preceding results it is evident that under fixed conditions a fairly constant percentage of the phosphorus present remains with the iron, in the ether separation. This phenomenon at once suggested a practical adaptation of the results obtained. In methods for the estimation of alumina, involving an ether separation of the iron, followed by an ammonia precipitation, it has been assumed that all the phosphorus present remained with the alumina and the other metals. In the Ether Method for the determination of alumina, as described in the Methods of the United States Steel Corporation for the Commercial Sampling and Analysis of Iron Ores, a correction is applied to the weight of the mixed oxides of iron, aluminum and phosphorus by deducting the combined weights of iron (determined by titration) as ferric oxide, and the total phosphorus content of the ore as

pentoxide. The conditions of experiment represented in Table I of this paper are practically the same as those existing in the above mentioned method. The approximate error incident to this method may, therefore, be calculated, and the proper correction applied.

For convenience in reference, Table III, appearing below, has been prepared for weights of phosphorus pentoxide and metallic iron; these conditions, of course, are to be observed in effecting the proper corrections. This table has been constructed from the average of the corresponding results presented in the preceding tables. The figures here tabulated are additive values, to be applied as direct increments to the

TABLE II.

Percentage of Phosphorus Retained in the Ethereal Solutions of Iron. Rewashed with 10 cc. of Ethereal ized HCl (1.13 sp. gr.).

Total Phosphorus Present.	Mixed Ores.	Total Phosphorus Present.	Ore plus Standard Phosphorus Solution.
	Percentage of Total Phosphorus Retained with 1 gm. Iron.		Percentage of Total Phosphorus Retained with 1 gm. Iron.
0.00104 gm.	22.3	0.001 gm.	22.0
0.002 gm.	15.8	0.002 gm.	15.4
0.004 gm.	13.4	0.004 gm.	12.7
0.008 gm.	12.3	0.008 gm.	12.2
0.016 gm.	11.6	0.016 gm.	12.2
	2 gm. Iron.		2 gm. Iron.
.....	....	0.00146 gm.	26.2
0.00208 gm.	24.7	0.002 gm.	24.6
0.004 gm.	24.2	0.004 gm.	23.4
0.008 gm.	23.5	0.008 gm.	22.8
0.016 gm.	23.3	0.016 gm.	22.4
	3 gm. Iron.		3 gm. Iron.
.....	....	0.00219 gm.	26.8
0.004 gm.	28.0	0.004 gm.	26.6
0.008 gm.	26.0	0.008 gm.	25.2
0.016 gm.	26.5	0.016 gm.	26.1

weight of the mixed oxides of aluminum, iron and phosphorus, previously noted. It will be seen that there is an increasing amount of phosphorus lost in the ether solutions with an increase of both the phosphorus and iron contents of the ores, though the percentage error in the present Ether Alumina Method is reduced by the use of large samples. Although corrective estimates are not given for intermediate variations of phosphorus and iron contents, it seems rational to assume that they may be approximated by interpolation.

In order to determine the behavior of increased amounts of phosphorus in the ether separation, several experiments were performed according to the conditions of the second series of determinations, with weights of phosphorus ranging upwards to one gram, a strong standard solution being prepared for this purpose. The results obtained indicate that about the same percentage of phosphorus remains in the ether solutions with the presence of relatively greater amounts, as with the largest weight (0.016 gm.) of phosphorus previously employed. Expressed dia-

TABLE III.

Weight Soluble Phosphorus Pentoxide in Ore.	Weight Phosphorus Pentoxide to be Added to Weight of Alumina Residue Found.		
	(Calculated from Table I.)		
	1 gm. Iron.	2 gm. Iron.	3 gm. Iron.
0.0023 gm.	0.0005 gm.	..... gm.	..... gm.
0.0046 gm.	0.0009 gm.	0.0015 gm.	0.0017 gm.
0.0092 gm.	0.0016 gm.	0.0029 gm.	0.0032 gm.
0.0183 gm.	0.0031 gm.	0.0055 gm.	0.0064 gm.
0.0366 gm.	0.0060 gm.	0.0108 gm.	0.0130 gm.
	(Caluclated from Table II.)		
	1 gm. Iron.	2 gm. Iron.	3 gm. Iron.
0.0023 gm.	0.0005 gm.	..... gm.	..... gm.
0.0046 gm.	0.0007 gm.	0.0011 gm.	0.0012 gm.
0.0092 gm.	0.0012 gm.	0.0022 gm.	0.0024 gm.
0.0183 gm.	0.0022 gm.	0.0042 gm.	0.0047 gm.
0.0366 gm.	0.0044 gm.	0.0084 gm.	0.0097 gm.

grammatically, the lines representing the percentage of phosphorus remaining with the ferric chloride in the ethereal solutions, if prolonged, would suffer no further, appreciable depression.

Laboratory of Duquesne Steel Works.

The U. S. Civil Service Commission, Washington, D. C., will hold an examination on May 4, 1910, at various cities throughout the country, to secure eligibles from which to make certification to fill two vacancies in the position of laboratory aid and engineer, $900 per annum each, in the Forest Products Laboratory, Madison, Wis., and vacancies requiring similar qualifications as they may occur in the Forest Service, unless it shall be decided in the interests of the service to fill either or both of the vacancies by reinstatement, transfer, or promotion.

The examination will consist of the subjects mentioned below, weighted as indicated:

Subjects.	Weights.
1. Arithmetic (simple tests in addition, subtraction, multiplication, and division of whole numbers, and of United States money)	10
2. Operation and care of boilers and steam pumps, motors, shafting, etc.	30
3. Training and experience (rated on application).	60
Total	100

METHODS OF ANALYSES OF THE POTASH SALTS.

By DR. H. ROEMER.

Leopoldshall-Stassfurt, Germany.

For the estimation of potash Fresenius's platinic chloride and Wense's and Caspari's perchloric acid are the two methods in general use in the potash industry. These two methods, here described, were adopted and accepted as international forms by the International Congress of Applied Chemistry at Berlin, 1903.

Besides these international methods the zinc-dust method, introduced by Feit and Bokemuller, is still much approved of by a few potash works. This method, which does not necessitate the precipitation of sulphuric acid in the analysis of salts containing a sulphate, has been described in detail by Bokemuller.

SPECIAL WEIGHTS.

According to stipulations made by Precht, it is now the practice in both methods to weigh out such quantities of the substances that a milligrm. of the weighed precipitate gives 0.1 per cent KCl, or 0.1 per cent K_2SO_4, avoiding thus the necessity of making a calculation every time.*

These quantities are:—

(1) For per cent KCl.

By Platinic Chloride—(a) 7.640 grms. $25 \times 0.3056 = 25 \times 2KCl : K_2PtCl_6$), or 30.56 grms.

By Perchloric Acid—(b) 13.4525 grms. $(25 \times 0.5381 = 25 \times 2KCl : KClO_4)$.

(2) For per cent K_2SO_4.

By Platinic Chloride—(a) 8.9275 grms. $(25 \times 0.3571 = 25K_2SO_4 : K_2PtCl_6)$, or 35.71 grms.

By Perchloric Acid—(b) 15.7218 grms. $(25 \times 0.3571 = 25K_2SO_4 : 2KClO_4)$.

ATOMIC WEIGHT OF PLATINUM.

The old figure of Berzelius, Pt=197.2, is the established atomic weight of platium and factor used in the platinic chloride method, because this figure takes into consideration the fact that the potassium platinic chloride precipitate does not exactly correspond to the formula K_2PtCl_6, but, according to Dittmar and Arthur, contains less chlorine, and in addition hydrogen and oxygen, which will not go off in the form of water at 160° C. As demonstrated by the classical research work of Frensenius, the results obtained by the use of the more exact Seubert atomic weight Pt= 195.0, are comparatively too high.

ALCOHOL.

For washing the potassium platinic chloride precipitate, alcohol of at least 96 per cent purity should be employed, although in a few methods, as, for example, those used by Müller and Morozwicz, 80 per cent alcohol is recommended. According to Dr. Tietjens the seemingly more correct analyses with 80 per cent depend on an equalising of errors; that is, the result which would be given by the traces of impurities left behind by the lower per cent alcohol is balanced by the result which would be given by traces of the potassium platinic chloride being dissolved by the 80 per cent alcohol containing more water.

As found by Prof. Precht, one part of potassium platinic chloride at the temperature of the room is soluble in 37,000 parts 96 (by weight) per cent alcohol; on the other hand, one part is soluble in 26,000 parts 80 per cent alcohol. Besides, the solubility of the compound calsium and magnesium salts is as great in 96 per cent alcohol, and that of the sodium salts is essentially greater than in 80 per cent alcohol. As other experimenters have also offered numerous opinions in favour of 96 per cent alcohol, its use is strongly recommended. At all events, much importance is to be attached to an absolutely clean platinic chloride solution.

PLATINIC CHLORIDE SOLUTION.

The separation of the platinum from the precipitates and the alcohol washings is carried out as follows:—The collected filters are boiled several times with water in order to free them from every trace of their former contents. The solution thus got, along with the alcoholic washings, are then poured into a porcelain basin of about 50 cm. diameter and heated on a water-bath, zinc or soda being added for reducing purposes. In the latter case, carbonate or bicarbonate of soda will be added to the boiling liquid, and heating must be continued until the liquid covering the dark deposit of metallic platinum is clear or only faintly yellow After the liquid has been decanted off, the deposit is boiled with water in order to remove any barium sulphate which had been present in the potassium platinic chloride, and which has been converted into barium carbonate and sodium sulphate. If the sodium sulphate is not fully removed by washing with water, on the subsequent treatment with hydrochloric acid the barium will be again converted into barium sulphate, which is very slightly soluble in hydochloric acid.

The reduced platinum is then washed several times by decantation with hydrochloric acid and water, the liquid being decanted off until it is thoroughly clean; the residue is finally evaporated to dryness on the water-bath, and ignited to remove any organic matter. The finely divided platinum is then placed in a larger porcelain basin, and boiled with concentrated nitric acid, and after the latter is poured off it is dissolved on the water-bath, when pure concentrated hydrochloric acid to the amount of four times the weight of platinum is added and heated on water-bath, and at the same time warm nitric acid is gradually added (1 nitric to 4 hydrochloric). When the platinum is wholly dissolved, the solution is concentrated by evaporation until a drop taken on a glass stirring rod crystallises immediately. During the evaporation of the liquid, water and hydrochloric acid have to be

*It is not advisable to calculate direct into per cent K_2O, as by doing this the chances of making mistakes are much greater.

added alternately for the removal of nitrous oxide compounds, while the conversion of platinous chloride into platinic must take place in fuming hydrochloric and very little nitric acid. On cooling the mass assumes a crystalline form ($H_2PtCl_6.6H_2O$), and this is taken up with water; the platinic chloride solution after filtration is diluted until 10 cc. of the solution contain 1 grm. platinum.

It is advisable to remove such impurities as platinous chloride and nitrous compounds before proceeding with the making up of the solution. This is done by adding a chemically pure 10 to 20 per cent solution of hydrogen peroxide, and when this is well shaken it will in a very short time take on the characteristic clear colour. By making use of scrap platinum from the laboratory, traces of iridium may be present; these can be removed by precipitation with ammonium chloride and subsequent reduction.

To test the purity of the platinic chloride solution take 7.640 grms. dry pure potassium chloride, and dissolve it along with 1.2 grms. sodium chloride in 500 cc. water. If the result shows the theoretical value of 100 the solution is quite pure.

(NOTE.—For further treatment see under muriate of potash. An addition of sodium chloride is advisable, because, without the same, impurities in the form of traces of sulphuric acid are overlooked in this test).

PERCHLORIC ACID.

The acid used in the perchloric method with a specific gravity of 1.125=19.57 per cent $HClO_4$ can be had commercially. It should not give a reaction with barium chloride ($BaSiF_6$); 10 cc. of the acid can be mixed with 10 cc. of 96 per cent alcohol without causing turbidity.

FILTERS.

The most serviceable filter for both the platinic chloride and perchloric acid methods for the estimation of potash is the Swedish filter-paper (Munktell) I F (9 cm.). It is advisable to hold the filter-paper before the lamplight before use to see that there are no small holes in it. As many otherwise excellent filter-papers on being treated with 96 per cent alcohol give a gain in weight often amounting to a few milligrms., the filter-paper before drying and weighing should be moistened with 96 per cent alcohol. When dry, the filter-paper should be weighed between two watch-glasses. In spite of their recognized excellence the Gooch and Neubauer crucible are not largely used in the potash industry.

PREPARATION OF THE SAMPLE.

After the sample of the material of which the analysis is wished has been well mixed and spread out on a table, small quantities from the spread out mixture are taken and well ground in a mortar until the whole of the sample passes through a sieve with a 1 mm. mesh; pieces which are difficult to grind should on no account be laid aside. This material, filled into a bottle, is now ready to be analysed.

(*a*) MURIATE OF POTASH.

Estimation of potash by the platinic chloride method.—7.640 grms. of the substance are dissolved in 500 cc. distilled water. In the case of salts containing more than 0.5 per cent SO_3, it is advisable to turn the sulphate into chloride beforehand. 20 cc. (=0.3056 grm.) of the solution, that is, of the filtrate, are measured into a shallow porcelain basin of about 10 cm. diameter, and after adding 5 to 6 cc. of the platinic chloride the solution is evaporated on the water-bath, being at the same time frequently agitated by giving the basin a gentle rotatory movement with the hand.

The evaporation can be carried on until dryness, as besides potassium platinic chloride, sodium platinic chloride is the chief salt present, which is more soluble in alcohol in a dry condition than when water is present. The dry residue is now moistened with a few drops of alcohol and thoroughly disintegrated by rubbing with a glass rod. To this is added 20 cc. 96 per cent alcohol, the contents of the basin being at the same time well stirred. The alcohol is then decanted off into a filter which has been heated at 120 to 130° C. and weighed warm until a constant weight has been reached (which takes about an hour), while care must be taken not to let the first of the poured off liquid touch the edge of the filter. Washing with alcohol is continued until the alcohol passing through the filter is quite colorless, and the residue of a golden-yellow color containing no orange flecks. It is very advisable to finally wash once or twice with hot alcohol of about 75° C. The precipitate can now be transferred to the filter, where it is washed with warm alcohol. Filtering can be hastened by the use of a moderately strong suction apparatus. When the filter is freed as far as possible of alcohol, it is folded, dried at 120 to 130° C., and weighed *warm* until constant weighings are found. 1 mgrm. K_2PtCl_6 then corresponds to 0.1 per cent KCl.

(*b*) PERCHLORIC ACID.

13.4525 grms. of the substance, to which 3 to 4 cm. of a solution of normal barium chloride containing hydrochloric acid is added, are dissolved in 500 cc. of water; 20 cc. of the solution contains 0.5381 grm. of the salt. If the salt contains more than 1 per cent SO_3 it is advantageous to precipitate this at boiling point. 20 cc. of the solution with 5 to 6 cc. perchloric acid are evaporated in a glass or blue enamelled porcelain basin until the odor of hydrochloric acid has disappeared and fumes of perchloric acid begin to form. The residue is allowed to cool, and then about 20 cc. 96 per cent alcohol are added, which contains about 0.2 per cent by weight of $HClO_4$ (d=1.125). The residue is thoroughly disintegrated, and washed several times with alcohol, which is decanted into a filter, treated in the same manner as before. Finally, the precipitate and filter are washed with pure alcohol; as little as possible should be used. This is done to remove the perchloric acid, which would otherwise blacken the filter. The filter is then dried (120 to

130° C.), and weighed. 1 mgrm. $HClO_4$ corresponds to 0.1 per cent KCl.

ESTIMATION OF SODIUM CHLORIDE (BY TIETJENS).

12.5 grms. muriate of potash are added to 25 cm. of a solution of potassium carbonate (3.6 grms. to the litre)* in a 255 cc. flask and boiled, and while the solution is kept in motion absolute alcohol is added to the same. The flask is then cooled, filled up to the 255 cc. mark, and well shaken for about a minute. To 100 cc. (=5 grms. salt) of the filtered solution in a weighed platinum basin, a few drops of strong hydrochloric acid are added and evaporated to dryness. The residue is ignited and weighed. In this mixture either the potassium chloride can be estimated by the platinic chloride or perchloric acid method, and by taking the difference the amount of sodium chloride can be found, or the amount of chlorine can be determined by titrating with decinormal silver nitrate solution, and from this the sodium chloride can be calculated as follows; —The chlorine contained is multiplied by KCl:Cl= 2.10266 (log.=32277), and from this result the weight of the alkali chloride is deducted. The remainder is now multiplied by NaCl:(KClNaCl)=3.6310 (log. 56003); thus the weight of sodium chloride is found.

(c) ESTIMATION OF MAGNESIUM CHLORIDE—BY PRECHT.

1. 25 grms. muriate of potash are put in a 500 cc. flask containing about 300 cc. water and dissolved. To this 10 cc. double normal caustic potash or soda are added. The solution is then brought up to 500 cc. and filtered. 50 cc. of the filtrate are measure out, and with phenolphthalein as an indicator are titrated with decinormal hydrochloric acid. The number of cc. of acid required are subtracted from the ten times increased factor of the caustic (by exactly doubling normal caustic=20.0); the remainder, now decinormal caustic, is multiplied by $4MgCl_2$:2000=0.1905 (in round numbers 0.2). This gives the per cent of $MgCl_2$ contained. The presence of lime compounds in the solution does not affect the result.

2. 25 grms. muriate of potash are dissolved in 160 cc. water in a 250 cc. flask. To this are added 25 cc. of a decinormal solution of calcium saccharate, and after the flask has been well shaken it is filled up to the 250 cc. mark. In a short time the voluminous precipitate of magnesium hydroxide can be filtered off, when 50 cc. of the filtrate are then taken, and with phenolphthalein as an indicator are titrated back with decinormal hydrochloric acid. The calculation is made in the same way as in case 1.

The calcium saccharate solution is prepared in the following way: 450 grms. quicklime and 450 grms. sugar are dissolved in 7 litres water, and well shaken for half an hour. After the precipitate has thoroughly settled, which lasts from two to three weeks, the solution is filtered, 450 grms. sugar being added to the filtrate. The solution should be kept in an air-tight bottle.

*In order to precipitate the magnesia and calcium compounds; a greater addition is to be avoided, as the dissolved sodium chloride separates out again very easily.

(d) ESTIMATION OF SULPHURIC ACID IN 98 PER CENT MURIATE OF POTASH.

50 grms. muriate of potash are dissolved in 500 cc. water. To 200 cc. (20 grms. of the salt) of the filtrate 1 cc. of concentrated hydrochloric acid is added, and the solution boiled with an excess of barium chloride. In a few hours the precipitate is filtered through a Gooch crucible filter and washed with hot water, being afterwards ignited and weighed.

Besides the gravimetric method a few works recommend Andrew's method, which, as it can be carried out more rapidly, is here described:

50 grms. of the salt are added along with 4 cc. concentrated hydrochloric acid to 150 cc. hot water in a 200 cc. flask. To this are added 10 cc. (for every 0.4 per cent SO_3 which the salt contains) of a half normal solution of barium chloride (61 grms. to the litre), and the solution is then boiled.

The same number of cc. of a corresponding solution of potassium bichromate are now added ($K_2Cr_2O_7$: 8 = 36.9 grms to the litre), and neutralized with a few drops of caustic alkali or ammonia.* The solution is again gently boiled, then cooled and brought up to 200 cc., shaken, and filtered to remove the barium sulphate and chromate. 100 cc. of the filtrate (which now contains an equivalent amount of chromate in place of sulphate) are acidulated with a few drops of concentrated sulphuric acid, and titrated with a solution of ferroammonium sulphate,† $6(NH_4)_2SO_4.FeSO_4.6H_2O$: 80 = 29.4 grms. and a few cc. concentrated sulphuric acid to the litre, with potassium ferricyanide‡ as indicator (Turnbull's blue reaction). 1 cc. ferroammonium sulphate solution corresponds to 0.002 grm. SO_3, or 0.008 per cent SO_3.

Titration can also be carried out with potassium iodide and an added solution of sodium thiosulphate. Proceeding from the above given amounts the potassium bichromate solution is exactly ten times as strong as the ferroammonium sulphate.

It is advisable to test the strength of the solutions before making use of them. In these tests one should begin with the former, which should consist of a pure well dried salt, and in this way and by the help of the Tuppel method the strength of the ferroammonium sulphate is determined.

(e) ESTIMATION OF WATER.

10 grms. of the salt are placed in a covered platinum crucible and heated over a small flame at a dull red heat for from ten to twenty minutes. The water contained is found by calculating the difference in weight before and after heating. In the case of salts rich in magnesium chloride, the breaking up of the magnesium chloride due to heating is prevented by cov-

*$K_2SO_4 + (2BaCl_2 + K_2Cr_2O_7) + 2KOH = BaSO_4 + BaCrO_4 + K_2CrO_4 + 4KCl + H_2O$; thus $1SO_4$ or SO_3 will be given as $1CrO_4$.

†$K_2CrO_4 + 6FeSO_4 + 10H_2SO_4 = 4KHSO_4 + Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 8H_2O$; 1Fe gives one-third CrO_4 or $\frac{1}{3}SO_3$. The ferroammonium sulphate solution is liable to change; therefore should only be made in quantities of a litre at a time, and kept in a dark bottle.

‡The potassium ferricyanide used must be quite free from potassium ferrocyanide

ering the salt in the crucible with well burnt lime or lead oxide.

II. SULPHATE OF POTASH AND SULPHATE OF POTASH MAGNESIA.

ESTIMATION OF POTASH.

1. *As Potassium Platinic Chloride.*—8.9275 grms. of the salt are dissolved by boiling in a 500 cc. flask in 300 cc. water, to which 20 cc. concentrated hydrochloric acid have been added. The sulphuric acid is precipited by adding barium chloride§ drop by drop from a pipette or burette to the boiling solution. To test if the sulphate is all precipitated add a grain of barium chloride to the solution; if no turbidity results all the sulphate has fallen out. Any excess of barium chloride can be removed by adding a few drops of normal sulphuric acid, otherwise the decomposition of barium platinic chloride through the alcohol will easily cause a higher result. A small excess of sulphuric acid makes little or no difference; only the solution with platinum chloride must not be evaporated beyond a syrupy consistency, otherwise the sulphuric acid, due to concentration, will break up the platinum salt. After precipitation of the sulphate and cooling the liquid is brought up to 500 cc., and 20 cc. (= 0.3571 grm. of the salt) of the filtrate are treated with 5 to 6 cc. of the platinic chloride solution, and further dealt with as before. 1 mgrm. K_2PtCl_6 corresponds to 0.1 per cent K_2SO_4. To the amount of K_2SO_4 found must be added 0.3 per cent, as the amount of potassium sulphate taken down with the barium sulphate precipitates is not wholly compensated for by the lessened volume of the solution through the presence of the bulky precipitate. In the case of sulphate of potash magnesia no correction is necessary.

2. *As Potassium Chlorate.*—15.7218 grms. of the salt art dissolved in about 700 cc. water in a litre flask, to which 30 cc. hydrochloric acid are added. The further treatment is the same as in the first case, with the difference that a smaller excess of barium chloride can be used, and instead of 20 cc. 40 cc. (0.6887 grm. of the salt) of the filtrate are evaporated with 5 to 6 cc. perchloric acid. 1 mgrm. $KClO_4$ corresponds to 0.1 per cent K_2SO_4. 0.3 per cent K_2SO_4 must be added to the estimated result.

III. POTASH MANURE SALTS* AND CRUDE POTASH SALTS.

1. ESTIMATION OF POTASH.

(a) *By Potassium Platinic Chloride.*—According as the precipitate K_2PtCl_6 is to represent KCl or K_2SO_4, 30.56 grms. or 35.71 grms. of the salt are dissolved by boiling with water, to which 10 cc. hydrochloric acid have been added, in a 500 cc. flask. After cooling the solution is brought up to 500 cc. 50 cc. of the filtrate are treated with barium chloride in a 200 cc. flask as in the case of sulphate of potash. To 20 cc. (=0.3056 grm. or 0.3571 grm. of the salt) of the solution, from which the sulphate has been removed, are added 5 to 6 cc. platinic chloride solution. This is evaporated until a syrupy consistency is reached, and analysis continued as before. If the sample is so finely ground that everything passes through a sieve of ½ mm. mesh it will be sufficient to weigh out 7.640 grms. or 8.9275 grm. of the salt.

(b) *By Potassium Perchlorate.*—In using perchloric acid, barium chloride is added to a 500 cc. solution of 13.4525 grms., or 15.7218 grms. of the salt, and 20 cc. (=0.5381 grm. or 0.62887 grm. of the salt) are treated in the usual way with the necessary amount of perchloric acid.

2. ESTIMATION OF TOTAL MAGNESIA.

10 grms. of the crude potash salt or kieserit are boiled for not less than an hour in 300 cc. water. After cooling, 50 to 60 cc. double normal caustic potash, and in the case of salts rich in calcium 20 cc. of a solution (1:10) of neutral potassium oxalate, are added to the solution, which is then brought up to 500 cc., well shaken, and filtered after being allowed to stand for a quarter of an hour. 50 cc. are then titrated with decinormal acid. The factor of caustic increased ten times (by exactly double normal, that is 20.0) is multiplied by five or six according to whether 50 or 60 cc. of the caustic were used. The number of cc. of acid used is subtracted from the above-mentioned result, and the remainder is multiplied by $MgSO_4$:200 =0.602 (roughly 0.6). As the separated magnesium hydroxide is not quite insoluble, 0.2 per cent has to be added to the result.

3. ESTIMATION OF MAGNESIUM CHLORIDE.

10 grms. of the finely ground crude salt are placed in a stoppered bottle of 250 cc. capacity along with 100 cc. 96 per cent alcohol, and well shaken for ten minutes. The solution is filtered, and 10 or 20 cc. of the filtrate are titrated with decinormal nitrate of silver solution. The salts, which contain over 6 per cent chlorine, soluble in alcohol, corresponding to 8.06 per cent $MgCl_2$, are assigned to group V. (carnallit salts), those with 6 per cent and under to group IV. (crude salts which are not carnallit trade name kainit—hard salt). This is, of course, only a conventional method. Owing to the extraction of magnesium chloride and the water contained in the salts the volume of alcohol will be increased. It is necessary in exact carnallit analyses to wash the residue in the filter well with alcohol, and bring the solution up to 500 cc. by adding water, and then by taking a certain volume (about 50 cm.) to estimate the per cent of magnesia.

4. ESTIMATION OF LIME.

Excess of ammonium chloride is added to the solution, and the lime is precipitated as calcium oxalate, and either weighed as calcium oxide or the calcium oxalate precipitate can be carefully dissolved in dilute sulphuric acid and titrated with potassium permanganate.

§ 50 cc. concentrated hydrochloride acid to the litre. Barium chloride often contains salts of potash, therefore should be frequently tested.

*In the case of mixed manures which contain ammonium salts and phosphates the latter must be removed before the analysis is proceeded with.

5. ESTIMATION OF SODIUM.

A solution (25 grms. of salt in 100 cc. water) is made with boiling water; this is filtered, and after the residue is well washed the filtrate is brought up to 500 cc. 200 cc. (=10 grms. of the salt) of the filtrate are acidulated by adding hydrochloric acid, and after heating treated with barium chloride in a 500 cc. flash until the sulphuric acid has been quite removed, but without adding excess of barium chloride. The liquid is brought up to 500 cc., and 50 cc. of the solution (=1 grm. of the substance) are evaporated to dryness in order to remove the hydrochloric acid. The magnesium chloride is then removed by treating with oxalic acid and igniting, and the residue is moistened with ammonium carbonate in order to transfer the calcium which has been formed into calcium carbonate. The alkaline chlorides, which are now freed from magnesia and lime, are weighed, and in the usual manner the potassium chloride is estimated with platinic chloride or perchloric acid. The amount of sodium chloride is calculated by subtracting the amount of potassium chloride from the total weight of alkaline chlorides; the result has then to be calculated into the different sodium salts.

ESTIMATION OF SULPHATE.

Besides the gravimetric method the following method of mass analysis by Wildenstein is practised by a few works, and is said to be a much quicker method.

5 grms. of the salt are dissolved in a flask and the solution heated to boiling-point. Neutral normal barium chloride is then added gradually from a burette to slight excess. (The point at which all the sulphuric acid has separated out can be fairly easily recognised by watching the steam bubbles, which when a sufficient amount of barium chloride has been added become opaque). The slight excess of barium chloride is now removed by titrating with a neutral half normal solution of potassium chromate. This solution is added until the liquid assumes a yellow colour; a single drop in excess will make this colour quite visible. The number of cc. of barium chloride run off (after subtraction of half the number of cc. of chromate solution used) are multiplied by 0.8, and this gives the per cent of SO_3 contained.

In the application of this method it is necessary to be convinced of the absence of other acids, such as HF, H_2CO_3, H_2SO_3, $H_2S_2O_3$, H_2SiO_3, H_3BO_3, and H_3PO_4.

7. ESTIMATION OF CHLORINE.

The per cent of chlorine is determined in the usual way, a neutral solution being titrated with silver nitrate, with potassium chromate or sodium arseniate as an indicator.

8. ESTIMATION OF INSOLUBLES.

10 grms. of the salt are dissolved by boiling in water and filtered through a weighed filter, which is then washed with warm water, dried at 120 to 130°, and weighed.

9. ESTIMATION OF WATER.

As in the case of muriate of potash.

COMPLETE ANALYSIS.

25 grms. of the sample are dissolved by boiling for an hour in a beaker containing 300 cc. water. The solution is then filtered through a weighed filter into a 500 cc. flask for the estimation of insolubilities. After the filter has been washed with warm water, and the filtrate cooled, the flask is filled up to the 500 cc. mark. 20 cc. (=1 grm. of the salt) are taken for both the estimation of lime and sulphuric acid; for the estimation of chlorine 20 cc. of the solution are taken, filled up to 500 cc., and 50 cc. of this solution (=0.1 grm. of the salt) are titrated. For the determination of magnesia 200 cc. of the solution are taken and treated with an excess of double normal caustic, and after dilution to 500 cc. filtered. 50 cc. of the filtrate (=1 grm. of the salt) are then titrated.

For the estimation of potash either a new solution can be made or 100 cc. of the prepared solution can be brought up to 200 cc. After filtration, 20 cc. (= 0.5 grm.) of the filtrate are treated with 8 to 9 cc. platinic chloride, and the analysis proceeded with in the usual way.

The calculations for the complete analysis are reckoned in the following manner:—From the total amount of sulphuric acid that part corresponding to the amount of lime found is deducted. After the estimation of magnesium chloride soluble in alcohol, the magnesia which is not combined with chlorine is calculated as sulphate, and the sulphate which is not combined with magnesia and lime is calculated as potassium sulphate (for instance, by a composition of glaserit, krugit, langbeinit, leonit, polyhalite, choenit, and syngenit). The remainder of the potash (from carnallit, douglasit, hard salt, kainit, and sylvinit) is given as muriate of potash, and the chlorine not combined with potassium and magnesium as sodium chloride. If the potash contained does not meet the whole of the sulphuric acid (after the corresponding amounts for lime and magnesia have been deducted), the remainder of the sulphuric acid is given as sodium sulphate, and any chlorine remaining is reckoned as sodium chloride.

In many cases the water estimation gives an idea of the nature of crude salts. For instance, hard salts, consisting of sylvine, rock salt, and kieserit, contain up to 5 per cent water ($1H_2O$ as $1MgO$). In kainit, which according to late discoveries has the formula $KCl.MgSO_4.3H_2O$, about 12 per cent water ($3H_2O$—$1MgO$) is present, and carnallit, $KCl.MgCl_2.6H_2O$, has even up to 26 per cent water ($6H_2O.1MgO$). Only it is not to be forgotten that the crude salts supplied in most cases are not chemical combinations but mixtures of different varieties of salts.

Italian raw silk to the value of $17,180,416 was shipped from Milan to the United States during 1909, which was an increase of $2,740,211 over 1908.

DETERMINATION OF CARBON IN IRON AND STEEL.

By MAX. R. TREMBOUR.

Chemical Laboratory, D. L. & W. R. R., Scranton, Pa.

The following method of determining carbon in iron and steel by direct combustion may perhaps prove to be of some interest, especially in cases where the results obtained by the solution of the steel in ammonium or potassium cupric chloride and following combustion of the separated carbon are rather doubtful, as is the case with many special steels.

The method consists in burning the steel drillings in a current of oxygen by aid of ferric oxide Fe_2O_3 and, if the drillings are very coarse, after addition of a small amount of powdered iron, which serves to start the ignition of the coarse sample by generating the required heat.

If in making the drillings care is taken to obtain them as thin and flat as possible and the drillings so obtained are then sifted between a 20 and 40 mesh sieve, they will burn readily, in most cases without the addition of powdered iron. To obtain such drillings in large quantity the author uses a drill the edges of which are notched in such a manner that the notches of the one edge correspond to the cogs of the other. However, almost any size of drillings can be completely burned by using a corresponding amount of powdered iron.

The apparatus used in the determination is the ordinary combustion furnace and train. A fused silica tube is preferably used, as this stands the high heat caused by the rapid combustion of the steel much better than a porcelain tube.

The iron oxide required can be easily obtained in satisfactory purity by heating and igniting iron chloride ($Fe\,Cl_3$). The powdered iron when used has to be standardized before use to determine its carbon content. The author preferably uses iron reduced by hydrogen, which can be obtained perfectly free from carbon by reducing the iron oxide manufactured as above in a stream of hydrogen. The lower the temperature is kept during the reduction, the more readily the iron powder obtained will burn. Most of the iron by hydrogen on the market contains carbon up to several tenths of one per cent.

The procedure is as follows: From 1 to 3 grams of the steel (the factor weights of 1.3635 grams or 2.7270 grams are a suitable amount) are weighed out and well mixed with about 1½ to 4½ grams of Fe_2O_3 and (if the sample is coarse) with 1 to 2 grams of powdered iron. The mixture is spread out in a porcelain boat upon a thin layer of Fe_2O_3 and care is taken that no pieces of the steel are much raised above the surface of the mixture. Then the boat is pushed into the combustion tube, all burners of which are lighted before to full heat with the exception of the three or four directly under the place where the boat is to be placed. After closing the tube and turning the stream of oxygen on, the last three burners also are lighted. The oxydation takes place in from one to two minutes, whereupon the oxygen is run through the apparatus for about 20 minutes more. Then the potash bulb is weighed as usual.

During the oxydation care must be taken that enough oxygen is introduced into the tube. As soon as the three burners under the boat are lighted, the bubbling in the potash bulb will cease, and at the same time the tube will become very hot and light around the rear end of the boat, where the oxydation starts. At this time the volume of oxygen introduced into the tube must be so increased as to keep up the bubbling in the potash bulb and must again be slowly diminished as the oxydation ceases.

If the operation has been performed all right, the material in the boat will be thoroughly fused with the exception of some Fe_2O_3 which was added in excess. A simple test for the complete combustion is to grind the mass in an agate mortar and then pour some acid upon it, when no effervescence should show up.

The layer of Fe_2O_3 is to prevent the material from sticking fast to the bottom of the boat, which when carefully handled will last for a large number of determinations. Instead of the porcelain boat, a platinum boat of large size can be used with much advantage.

The following results obtained show that the method gives very satisfactory checks with other methods, which are much more troublesome and protracted:

Steel.	Direct Combustion as Above.	Solution in Pot., Cupr., Chlor. and Combustion of Residue.	Volatilization of the Fe in Cl and Combustion of Residue.
Bess. I.....	0.350	.....	0.350
Bess. II.....	0.926	.....	0.928
B. O. H.....	0.805	0.802	.....
	0.805	0.822	.....
B. O. H.....	0.772	0.768	.....
	0.687		.....
B. O. H.....	0.689	0.676	.....
	0.686	0.687	.....
B. O. H.....	0.714	0.720	.....
Ni. Cr.....	0.608	0.622	.....
Vanadium	0.330	0.335	.....
	0.332	0.327	.....
		0.342	.....
		0.348	.....

Consul Isaac A. Manning, of La Guaira, reports that a number of cane growers of Venezuela have entered into a compact by which each agrees to deliver 20 per cent of his product of papelon, or crude brown sugar, to a central directorate for exportation. The first shipment of 50 tons sent to London is expected to realize 11s ($2.64) on each 110 lbs.

METALLURGY.

ELECTROCEMENTIZING.*

By ALFRED SANG.

The hot process is the one usually adopted to coat or galvanize iron and steel wire, to be used for fencing, or wire goods exposed to the weather. The process requires that the wire be drawn successively through five operations, thus:

1. Annealing in a tubular furnace. 2. Cleaning, that is, removing the iron rust or scale produced by bringing the hot wire in contact with oxygen of atmosphere, and also the traces of carbon left from the grease during the wire-drawing operation previous to annealing. 3. Fluxing with chloride of zinc, or else a mixture of salammoniac and glycerine floating on a zinc bath at about 500° C. 4. Coating the wire by drawing it through molten zinc which has a temperature of about 500° C. 5. Wiping the coated wire with asbestos wipers; then drawing it through water to cool previous to winding it on the take-up frame.

The objections to the hot process are: 1. The annealing may be imperfect. 2. The acid-picking process causes the absorption of hydrogen, which not only hardens the surface, but promotes corrosion and prevents the zinc properly alloying with iron of the wire. 3. The flux causes blisters between zinc and iron in which traces of chlorides are imprisoned and assist in corrosion; the wiping destroys the pockets themselves, leaving areas where the coating is practically non-adherent. 4. The zinc deposited is high in iron and therefore more readily scaled off than pure zinc and sooner destroyed by moist air and other agencies. 5. The wiping is difficult to control; if too close it will very often cause streakiness, the protection to the iron being that afforded by the amount of zinc at the thinnest spots; if the zinc is wiped too cold there occurs a transversal crackling not unlike the hair cracks in a troweled surface.

The hot process is not a simple one; it only appears simple when compared to recent processes, because there are two generations of experience back of it.

The following process has been tested in a modest way and, it is hoped, will soon be tried, for a verdict of life or death, on a small commercial scale.

The claims to attention for this process are its comparative simplicity, the fact that it lends itself to scientific control and the quality of the product. It is doubtful whether it can equal the low costs for hot galvanizing unless it be applied on a very large scale.

The principle involved in "electrocementizing"—cementizing being the process of depositing metals by cementation, of which sherardizing† is a form—is by no means new. We find in the Bulletin de la Société de Chimie et de Physique for the year 1805, page 374, that M. Dumas has found a means of zinc-coating iron by burying it in oxide of zinc and powdered charcoal and heating it to redness. Since then, many processes depending on the reduction of oxides or oxidized dusts in contact with the articles to be coated have been tried, usually with indifferent success.

The novelty of electrocementizing consists in the method of heating by electricity, the heat being directly applied to the articles by using them as resistances. It is only applicable in practice to articles of small cross-section, such as wires and strips, although in theory it may be applicable to larger goods, and if carried out on a very important scale could undoubtedly be applied to thin sheets and tubes.

Referring to the diagram: the coating chamber or furnace *a* is built of iron plates and lined with such refractory materials as are used in zinc smelting furnaces; it is filled from the top with a mixture of crushed coal and oxide of zinc. The wire comes off the reels *b* and passes over and around brass contact sheaves *c* which are equal in number to the strands of wire which the furnace will treat at one time, and are mounted tight on a common shaft from which they are insulated by non-conducting bushings. This shaft, by revolving, leads the wires and relieves the tension on them. The single sheaves *d* at each end of the shaft are connected through the proper rheostat to the poles of a suitable transformer supplying alternating current at a low tension which may be varied within certain limits. The intermediate sheaves are paired by means of common hubs so that the current may pass freely from one to the other in each pair.

The wires now pass between the hinged aprons or flaps *e* and into the lower part of the furnace, then over another series of sheaves *f* inside and at the rear end of the furnace, these sheaves being similar in every respect to the double sheaves on the outside, but staggered in relation to them, so that the near sheave of each outside pair is in line with the far sheave of each inside pair; the wires then return through the upper part of the furnace and through a second set of hinged flaps, to the take-up frame which would, if shown in the drawing, stand to the right of the paying-out reels.

The entrance and exit flaps will allow the passage of

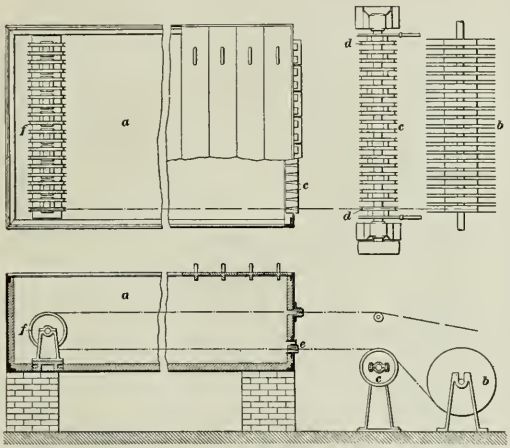
*From Transactions Electrochemical Societies, October, 1909.

†Sherardizing is a process for coating iron, steel, and other metals with zinc. The metal to be coated is enclosed in an air-tight iron box, lined with graphite and charged with zinc dust. About 3 per cent. of finely pulverized carbon is added to the zinc dust, to prevent the formation of too much zinc oxide. The box is heated for a few hours at a temperature of from 500° to 600° C. during which time a coating of zinc is formed on the metal.

the loops which connect successive strands end to end; the material falling through these openings will be collected and fed back to the furnace.

When all the strands of wire are in place and connected, therefore, in series, the current will pass zigzag-wise in and out of the furnace and a wire resistance of considerable length will thus be afforded. The entire system forms a resistance grid on a very large scale.

As the heating up is necessarily rapid and as no useful purpose can be served by maintaining the full temperature once it has permeated the wire, it is probable that a very short furnace will suffice, in which case it would be necessary to alter the design of the plant



Sketch Showing Arrangement of Electro Cementizing Furnace.

in order to afford the wire a sufficient length of time to cool in a non-conducting medium and out of reach of the air. As it leaves the furnace the wire might be led to the take-up reels through tubes, in order to prevent chilling. If, for any reason, a wire breaks or pulls out, the simplest thing to do is to cut it out entirely and connect up the sheaves between which it ran by a copper conductor or a standard resistance on the outside, until such time as the furnace is closed down for cleaning, inspecting, or repairing.

The wire is quickly brought to a bright cherry red in the furnace, at which temperature all grease is volatilized, scale or rust is reduced by the carbon, and occluded gases are driven out; at the same time, the zinc oxide in immediate contact is reduced and, as vapor, soaks into the "pores" of the metal, which are well opened by the heating, and condenses on the surface as the heat drops. As the wire returns through the upper part of the furnace it cools down slowly from a temperature considerably above its recalescence point, so that it is annealed. With low-carbon steels an excess temperature of annealing of 200 or 300 degrees is not likely to seriously affect the quality of the wire. The coating is of the color of freshly electrodeposited silver. The quality of the product is mostly due to the alloy of zinc and iron. Iron which has absorbed an almost infinitesimal amount of zinc by being exposed to zinc vapor in a reducing atmosphere, is most difficult to corrode and resists a solution of hydrochloric acid in a most remarkable manner.

The oxide and finely divided carbon from a non-conducting mass, and the heat emanating from the wires will accumulate in the furnace until a constant temperature, not far below the reduction point of the oxide, will be reached; this will greatly reduce the amount of current required to operate the process. After the operation is under way, the resistance of the hot wires will be much greater than that of the cold wires.

Most of the time consumed in "sherardizing" is spent in forcing the heat from the outside through a non-conducting mass of zinc dust; in the meantime, most of the heat units go up the flue. The thermal efficiency of electrocementizing is better and will go far toward balancing the excessive cost of electric heat.

It appears, therefore, that the new process would combine in itself the annealing furnace, the cleaning process, and the zinc bath and do away entirely with the fluxing and wiping. While the cost of the heating will surely exceed that of the hot process, at least until the furnace has reached its constant temperature, the cost of installation, maintenance, and depreciation, taken one with the other, will probably be lower than for the hot plant, the cost of the zinc will be much less, standing at about 3½ cents on a 5 cent spelter market, with less waste, and the labor cost should be little, if at all, in excess of what it is at present; the wire will run more slowly, but there will be a compensating increase in the number of strands.

A serious objection has been offered with regard to the temperature of the wire. The estimated maximum temperature of 900° C. is high, and there is undoubtedly danger of the wire breaking inside of the furnace or, at least, being elongated; most galvanizing wires are of small gage, No. 12, for instance, being a very important size. The driving of the contact sheaves is calculated to relieve the tension created by the take-up reels and breakage from sag need hardly be feared and could easily be prevented. However, the criticism is a very legitimate one; trial on a commercial scale will reveal the problem, if it exists, and it can then be attacked and, probably, successfully solved. The mechanical and electrical elements of the process are by no means complicated, and the most valuable criticisms and hints will come from those who know, from their experience with zinc reduction furnaces, what is likely to take place inside the coating chamber.

Oxides of other metals besides zinc may be used. Zinc dust deposits zinc at a much lower temperature, and might be useful for wire which must not be annealed, but its use is open to many serious objections. It is costly and by aging it becomes in part converted into the carbonate of zinc, which requires a higher

temperature of reduction at which, unfortunately, carbon dioxide begins to act and, unless special precautions be taken to maintain an atmosphere rich in carbon monoxide, the result is a gray coating of mixed zinc and zinc carbonate which suffers further decomposition, until, after a few months, it crumbles when the articles are hammered or bent. All dark-colored "sherardizing" is more or less in this condition, and the sulphate of copper test, to which inspectors cling as to a fetish, is worthless as a test of quality, its limited value being in connection with coatings of zinc and not of zinc carbonate. Again, the use of zinc dust requires an air-tight furnace, which, in itself, would suffice to make the process uncommercial.

Zinc oxide, on the other hand, having a zinc content of 80 per cent, is an intermediate product in the manufacture of spelter, does not require an air-tight furnace, is not injurious to the workers, like zinc dust, and does not deteriorate, nor, on account of absorption of hydrogen from moisture, call for restrictions in respect to its storage, by fire insurance companies. Most important of all, its reduction yields a coating of pure distilled zinc which is thoroughly alloyed to the metal underneath.

VANADIUM-BRONZE IN MARINE CONSTRUCTION.*

Vanadium is one of the most interesting of the rare metals that have made their way into commercial world within the past few years. In steel, it has given remarkable results and its effect seems to be to toughen it without decreasing its elastic limit, and to produce an "anti-fatiguing" quality so that it will withstand a shock in a wonderful manner. Vanadium also has a strong deoxidizing property, unites with nitrogen readily and removes it from the metal to which it is added, and at the same time, an excess imparts special properties. By the use of vanadium, therefore, peculiar effects have been obtained in special steels that appear to have been impossible with elements other than vanadium.

Vanadium itself is usually considered a rare element, although it is more widely distributed than generally imagined. It can scarcely be called a common element, however, and perhaps it would be better to say that it is one of the more common of the rare elements. The principal source of vanadium at the present time is in Peru where it exists in the form of sulphide. It is mined there and transported to Callao from whence it is shipped to Pittsburgh for refining and reduction to the metal. Strange to say, vanadium is quite a common ingredient in caustic soda which frequently contains as much as 0.004%. An amount quite small in one sense, but large in another when it is considered that it is an impurity and a rare element. As soap is made of caustic soda, one writer has made the statement that practically all common soap contains vanadium.

Vanadium was discovered over a hundred years ago, and it is only with the past few years that any commercial use has been made of it. It is a silvery white metal of a specific gravity of 5.6. It is therefore, lighter than zinc or copper, but heavier than aluminum. It is really about half way between zinc and aluminum. Its melting point is quite high, and according to an authority, it is in the neighborhood of 3,600 degrees F. It is much higher than the melting point of platinum or steel.

In the smelting of vanadium from its ores, the pure metal is not produced, but an alloy with other metals. If iron is used in the smelting, ferro-vanadium is produced. With copper, a cupro-vanadium is obtained and this alloy is what is used in the manufacture of vanadium-bronze. By first alloying the vanadium with the copper, an alloy with a compartively low melting point is obtained so that it melts readily and may be easily introduced into the common bronzes.

The first concern to take up the making of vanadium-bronzes in the United States, seems to be the Victor Metals Co., of East Braintree, Mass., to whom we are indebted for the photographs of the castings herewith shown. This plant has recently passed into the control of the Vanadium Metals Co., of Pittsburgh, Pa., who will use it for the making of vanadium-bronzes for the trade. To the superintendent of the plant, Victor Lassen, belongs the credit of first producing commercial vanadium-bronzes in a successful manner.

The bronze made by them for use in marine-work resembles manganese-bronze in appearance and, like it, also contains considerable zinc and a small quantity of aluminum for imparting good casting qualities to the mixture. A small quantity of vanadium is also used and to this, it is claimed, the superior qualities of the bronze are due. Various grades of the vanadium-bronze are made, depending upon their use. It may be rolled hot, forged, or cast in sand. The mixtures, however, must be changed in each case to adapt it for the different purposes.

*From *The Brass World*, February, 1910.

According to the annual report of the United States Steel Corporation the production of its several subsidiary properties was as follows in gross tons:

Iron ore mined	1,824,863
Coke manufactured	13,500,112
Coal mined (not including that used in making coke)	3,080,021
Limestone quarried	3,496,071
Blast furnace production (pig iron, spiegel, ferromanganese and silicon)	11,618,350
Steel ingot production	13,355,189
Rolled and other finished steel products for sale	9,859,660
Spelter	27,853
Sulphate of iron	33,582
Universal Portland cement, bbls	5,786,000

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.
HENRY WYSOR, Metallurgical Editor.
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NOTES AND COMMENTS.

Platinum to Be Higher.

Refiners of platinum are worried by reports which they have received from Russian sources indicating that the Czar's government will put into effect in the next month or two a new plan for controlling the industry and more than doubling the price. The refineries which are in the Maiden Lane district get more than 95 per cent of their crude platinum from the Ural Mountains. Under the plan upon which the Russians have been working for a year all the platinum will be refined in their country.

The commission appointed by the Russian government nearly a year ago was directed to submit a report and to recommend a minimum price at which the refined platinum may be sold in the next year. The commission is said to have agreed upon a price of 2,100 rubles, or $710, for a pound of platinum comprising 83 per cent of the pure metal.

The refineries in New York are now selling pure platinm for $29 for a Troy ounce, nearly 50 per cent more than the price of gold. The price of platinum has gone up $5 an ounce in the last year and the refiners say that it is sure to go much higher, irrespective of the action of the Russian commission.

All the refiners say that the consumption of platinum has vastly increased in the last three years. At one of the largest refineries it was said that fully 200 per cent more platinum is now being used than ever before and that the consumption is now much greater than the production of the mines. The refiners are buying platinum scrap from all possible sources so as to remelt it and use it for the current demand. It is figured that 40 per cent of the platinum sold in the last year by refiners was the remelted scrap.

Anaconda Copper Co. Sued.

The Federal government has begun suit against the Anaconda Copper Mining Company to compel that company to operate its great smelting plant in such a manner as to end widespread destruction of the surrounding national forests. A bill in equity was filed March 16th at Helena, Mont., and this statement was issued later by the Department of Justice:

"This suit was not filed until every possible friendly means for securing a change of smelter methods had been exhausted. Efforts to secure a cessation of the smelter injuries were under way some time before the close of President Roosevelt's administration and the companies were then notified that suit would be brought unless definite action was taken by the smelters to stop the wholesale destruction of the forests resulting from the distribution of sulphur and arsenic fumes over a wide area of country. Instead of attempting to remedy the situation the companies represented to President Roosevelt that they could operate their plant in no other manner than that then in vogue and that it was better for the government to submit to the injury to its national forests than to close the smelter plant.

"President Roosevelt ordered a full investigation and personally conducted the hearings of the matter, all of which ran over a period when they sought to avoid being sued and were not new. They were identical with those made in two other suits under which similar injuries were stopped, one case being by the United States against the Mountain Copper Company in California and the other by the State of Georgia against the Ducktown, Tenn., companies.

"In each of these cases the smelter companies declared that the smelters could not be operated in any manner different from that then in vogue and that any action by the court would mean the closing of the mines and smelters and the discharge of thousands of men.

"Injunctions were, however, granted in both these cases, but neither the smelters nor the mines were closed. Instead the companies spent the money necessary to convert the harmful fumes into a valuable product and many additional men were given work. It was, however, contended on behalf of the Montana smelters that they could not do as the California and Tennessee companies had done, convert their fumes into acid, because they were of a wholly different character from those of the Tennessee and California smelters. A full investigation of this claim by leading experts has, however, satisfied the government of the entire feasibility of converting at Anaconda the fumes into acid and that there are large phosphate deposits near Anaconda which can be used in connection with such acid in the manufacture of fertilizers, of which the Western soil is more in need than that of the South.

"Being therefore satisfied that the present methods of operating the smelters are not only destructive of natural forests but unnecessary, the Attorney-General has caused the bill in equity to be filed and will press the suit vigorously for a decree, unless, as is hoped, the companies will now voluntarily co-operate with the government to bring about a termination of the existing conditions at the earliest possible moment."

Sterilizing by Light.

Many investigations are now being carried out in France on the employment of ultra-violet light for the

sterilization of liquids, since this method seems to offer a neat solution of the difficult and important problem of sterilizing drinking water. The cost of sterilization by it promises to be less than that involved in the use of ozone, and hence a great number of appliances are being studied for the practical application of the process.

For the most part mercury vapor lamps are utilized, the favorite types being the Cooper-Hewitt, made by the Westinghouse Company, the Heraeus, and that of the Quarzlampengesellschaft.

Some experimenters, such as MM. Courmont and Nogier, immerse the lamp in the liquid which is to be sterilized. This arrangement has the advantage that, as the ultra-violet rays are strongly absorbed by air, it assures the greatest efficiency of the apparatus. On the other hand, in these conditions the lamp is exposed to sudden changes of temperature that are apt to break the quarty tubes, which are relatively expensive on account of the difficulty of manufacture.

An elaborate investigation by M. Victor Henri on the action of the ultra-violet light will serve as a technical foundation for the new industry which seems likely to be founded on this method of sterilization. In the first instance, his studies have referred to transparent liquids such as ordinary town water, water of the Seine, and water infected with various microbes. The bacteriocidal action of the rays varies greatly with the distance at which the bacteria are placed from the lamp. Thus, in order to sterilize water containing bacillus coli with a Westinghouse Cooper-Hewitt lamp of 110 volts an exposure of 300 seconds was required at a distance of 60 cm., of 180 sec. at 40 cm., of 20 sec. at 20 cm., and of 4 sec. at 10 cm. With a lamp of 228 volts the time of exposure was 30 sec. at 60 cm., 20 sec. at 40 cm., 4 sec. at 20 cm., and less than 1 sec. at 10 cm. The temperature has scarcely any effect, the time necessary for sterilization not being sensibly reduced even if the microbial liquid is frozen, provided that the ice be transparent. The rapidity of the action is not the same for different bacteria.

The Westinghouse Company of Paris is actually constructing apparatus for the domestic sterilization of water. This works with a lamp of 110 volts 3 amperes, and can yield from 400 to 1,200 liters of sterilized water per hour. The lamp is not immersed, but is arranged within an enamel vessel, the water circulating beneath it in fan-shaped tubes, which bring it three times under the influence of the radiation.

For opaque liquids, such as milk, wine, or beer, a very thin layer of which is sufficient to absorb the ultra-violet rays entirely, sterilization can only be effected if the liquid is exposed in very thin layers. In the case of milk, for example, the thickness of the layer must not exceed 25 mm.

M. Billion-Daguerre keeps the liquid in immediate contact with the quartz tube. He has also constructed an apparatus in which the ultra-violet rays are produced by the electric discharge in a rarefied atmosphere of carbon monoxide, carbon dioxide, sulphuretted hydrogen, or sulphurous acid. In this case the lamp is not immersed.

BOOK REVIEW.

Text Book of Ore Dressing. By Robert H. Richards, assisted by E. S. Bardwell and E. G. Goodwin. 16x24. Cloth. XI—702 pages. 354 illustrations. Price $5.00. McGraw-Hill Book Company, New York. 1909.

The main subjects treated are as follows: General Principles. Part I.—Preliminary Breaking. Part II. —Final Crushing. Rolls, Gravity Stamps and Amalgamation, Grinders other than Gravity Stamps, Laws of Crushing. Part III.—Separating, Concentrating or Washing. Preliminary Washing and Hand Sorting. Preparation of the Crushed Ore for Concentration. Principles of Screen Sizing and Classifying. Coarse-Sand Concentrating, Fine-Sand Concentrating, Slime Concentrating, Miscellaneous Processes of Separation. Part IV.—Accessory Apparatus. Part V.— Mill Processes and Management. Management. Mill Principles and Processes, General Considerations. Part VI.—Coal Dressing.

Inseparable and indispensable as the industry of ore dressing is to other industries it constitutes a distinct branch of engineering art. As a study it may properly be classed as a separate branch of applied science. Between the subjects of mining and metallurgical engineering ore dressing is the connecting link, as indispensable to the one as to the other. No course either in mining or metallurgy is complete unless it deals very considerably with the preliminary treatment of ores.

Prof. Richards' book is the first comprehensive text book on ore dressing, and should arouse great interest, especially among teachers and students of this and allied subjects. It will be welcomed as coming from so eminent an authority and teacher. The author's successes in practice and in writing are too well known for recital here. The new book is a condensation of the author's well known treatise, "Ore Dressing," now filling four large volumes. It has the clearness, thoroughness and reliability of his former books without being burdened with details of practice. Much descriptive matter and data relating to machinery and practice in different localities is eliminated, and consequently the book will not soon be out of date. It would have been better, perhaps, if the process of elimination and condensation had gone further, resulting in still greater emphasis on the principles. While such a criticism would be made by some teachers, all will concede that the subject is treated thoroughly in both the academic and the technical sense. Expressed in a few words, Prof. Richards' book is a practical presentation of the principles and practice of ore dressing.

INDUSTRIAL AND PLANT NEWS.

Boiler Compound.—An organization of boiler compound men has been perfected to manufacture and compound chemicals for boiler treatment. The new organization is incorporated under the name of Green, Hook & Co., with main office in the Hudson Terminal Building, New York, and branches in Boston, Philadelphia, Baltimore, Norfolk and Havana. The main laboratory and works are in Jersey City, N. J. Another is under construction in Baltimore.

China.—The National China Company of East Liverpool, O., has bought the Dresden China Company's six-kiln plant at Salineville, Ohio, and will operate it with 200 employes, beginning April 1.

The pottery has been idle for two years, and was bought from a banking firm representing the bondholders.

Coke.—When Mr. A. L. Colby returned from Europe a year ago he began to collect information proving the advantages of Lehigh Valley, Pa., for a large coke plant. The report he sent to Germany was so favorably received that negotiations were begun, which will soon result in the addition to the plant of the Bethlehem Steel Company of a coke plant. By this German method of making coke no smoke is produced. It is condensed and produces by-products which find a ready market. The gas emitted will be used in the steel plant.

Fertilizers.—The construction of the fertilizer plant of the Atlantic Southern Chemical Co., Greensboro, N. C., will begin during the next 15 days on a site already secured, and will have a capacity of about 25,000 tons.

Iron.—The first blast furnace of the new smelting works in course of erection at Bagoli, near Naples, was lighted and brought into working condition on February 9. The second furnace is expected to begin working early this year. The new works, which will use Elba ore, are to embrace three furnaces, with a total daily output of 600 metric tons of pig iron, while there are at present in Elba three furnaces with the same aggregate output.

Iron.—The Temple furnace of the Temple Iron Company and the Emaus furnace of the Reading Iron Company will both resume in a few weeks because of the improved condition of the iron trade.

Iron.—The new modern blast furnace of the E. & G. Brooke Iron Company at Birdsboro, was blown in without ceremony. Instead of firing by the old style of applying the torch, 12 employes with red-hot irons applied the fire.

Iron.—The Russian steamship Korea, bound from Norway to Philadelphia, sank March 1, about 900 miles west of Queenstown, her crew being rescued by a passing liner. News of the disaster reached Philadelphia March 5. The Korea was loaded with iron ore taken on at Narvik, Norway, for Philadelphia, and it is believed that the bad weather caused this heavy cargo to shift and eventually sink her. The ore was consigned to the Reading Iron Company.

Portland Cement.—The Federal courts of New York, last week named William F. Allen receiver for the Seaboard Portland Cement Company, of No. 225 Fifth avenue, New York City, and Olsen, N. Y., and an equity suit brought by George A. Beaton on behalf of bondholders. The proceedings were preliminary to a reorganization of the company and were taken to protect the assets which are estimated at over $1,000,000. There is a bond issue of $2,000,000 and the liabilities outside of the bonds are not large.

The company was incorporated in July, 1907, with an authorized capital of $5,000,000. The company purchased 700 acres of land at Olsen on the Hudson near Catskill and proceeded to construct a large cement plant.

Powder.—The Detonite Company, with a capital of $500,000, was chartered at Columbus, O., last week, by G. M. Peters, O. E. Peters, W. E. Keplinger, F. C. Tuttle and B. B. Tuttle, of Cincinnati. The company will manufacture powder for use in mines, the invention of G. M. Peters.

Tin Plate.—The smallest tin plate plant in the world, the 3-mill establishment of the Alcania Tin Plate Company, at Avonmore, near Apollo, Pa., closed this month for an indefinite period. The tin house will continue operation until the stocks are cleaned up.

The plant makes only coke tin plate. The plant was idle for a long time, but started in March, 1908, and has been running regularly since. The company is understood to be short of crude steel, and unwilling to pay premium prices in the present state of the tin plate market.

Tungsten.—Pennsylvania capitalists are reported to be endeavoring to obtain control of the tungsten ore deposits near Round Mountain, Nevada. The largest producing district to-day is in Boulder county, Colo., but the entrance of the eastern interests into the Round mountain district is expected to affect conditions. The Round Mountain Monster Company is owned by San Francisco people, but the Pennsylvania interests control the Soshone Tungsten Company and lately have bought up all the surrounding property.

The consumption of tungsten by the General Electric Company for the past year amounted to 200,000,000 tungsten lamp filaments, but it is asserted that this will not equal one-tenth of the demand in this year.

Identified with the Pennsylvania-Round Mountain interests are Stanley P. Allen, Scranton, Pa., and Robert C. Adams, president of the Watres' Manufacturing Company, of New York.

Stock Food.—A plant will be constructed in Memphis, Tenn., by the International Stock Food Co., International Exposition Bldg., Minneapolis, Minn. It is to have a capacity of 300 tons per day, and is to be ready for operation by the middle of August. The plant will give employment to 75 persons from the start. M. W. Savage is at the head of the enterprise.

Bakery.—The Banner Grocers' Baking Co. of Cincinnati, O., will soon proceed with the erection of its $100,000 plant at the northwest corner of Oak St. and Stanton Ave., Walnut Hills. Surveys of what is generally known as Bullock's Field have been completed. The Reliance Engineering Co., Fourth National Bank Bldg., has been given the commission for laying out the engineering part of the plant. The lot is 125x300 ft. The structure at the corner will be of two stories and the rear part but one. There will be 21 ovens with a daily capacity of 110,000 loaves of bread. The interior of this bakeshop will be lined with white glazed tile. There will be a convention hall, 40x100 ft., which will be for the use of persons allied with the baking industry. The power plant will be 45x65 ft., and will have a capacity of 200 K. W. Besides this, there will be a matzos bakery.

Brass.—The National Fulton Brass Mfg. Co. of Detroit, Mich., has purchased a site at the corner of East Grand Blvd. and Chene St., where it will build a manufacturing plant at an estimated cost of $100,000. John F. Harrington, president, 22-28 Brush St.

Varnish, Etc.—The Glidden Varnish Co., Ltd., organized in Canada, on March 2, 1910, has purchased the plant, business and good will of Blackwell Varnishes, Ltd., at Toronto, Ont., Can. The plant is now being remodeled and the capacity of same very largely increased in order to handle better the rapidly increasing trade of the Glidden Varnish Co. of Cleveland, O., of which the Canadian plant will be a branch, and at which all the Glidden products will be manufactured, including Jap-A-Lac, concrete finishes and water proofings.

RECENT PATENTS.

The following recent patents relating to Industrial and Engineering Chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill building, Washington, D. C.

945,071. Manufacturing *Bituminous Paving.* Joseph H. Amies Philadelphia, Pa., January 4, 1910.

945,221. Method of Removing *Hair from Hides.* Lewis Cheeseman, Scranton, Pa., January 4, 1910.

945,291. *Shoe-Bottom Filler.* Andrew Thoma, Cambridge, Mass., January 4, 1910.

945,307. Process of *Burning Cement.* Henry L. Doherty, New York, N. Y., January 4, 1910.

This is a process of burning cement comprising producing a clinkering flame in heat-conveying relationship to a traveling stream of calcined cement material, subdividing the gases from such flame into a plurality of relatively small currents, passing each such current into effective heat-radiating relationship to a relatively small traveling stream of cement material to calcine the same and maintaining such current at substantially uniform distance from such cement material during such passage and finally uniting such small streams of calcined material in proximity to the clinkering flame.

945,313. Process for the Treatment of Peat Fiber and Its Manufacture Into Paper, etc. Ludwig Franz, Admont, Austria-Hungary. January 4, 1910.

945,331. Method of *Preventing the Destruction of Coke-Oven Walls* Through the Alkalies Contained in the Charge. Heinrich Koppers, Essen-on-the Ruhr, Germany. January 4, 1910.

945,332. Process of Obtaining *Ammonia from Gas.* Heinrich Koppers, Essen-on-the-Ruhr, Germany. January 4, 1910.

945,394. Process of *Treating "Spent" Pulping Liquids.* William J. Hough, Toledo, Ohio, January 4, 1910.

This is a process of treating "spent" pulping liquors containing resinous salts which consists in separating the resinous salts therefrom, and then subjecting the residue to destructive distillation to produce an oil suitable for creosoting or other purposes.

945,559. Process of Producing Solutions for *Spinning Artificial Threads and the Like.* Rudolph Linkmeyer, Bremen, January 4, 1910.

945,567. Roasted *Sulphurized Grain.* Eduard Meyer, Friedrichswerth, Germany. January 4, 1910

945,583. Process of *Manufacturing Mineral Wool.* Thomas B. Parkison, Muncie, Ind. January 4, 1910.

This process is for the production of water-proof mineral wool by projecting a blast of molten slag in the form of highly heated filaments and subjecting the same to the action of oil whereby each individual filament is coated therewith.

945,612. Process of Extracting *Turpentine and Rosin.* Benjamin F. A. Saylor, Rome, Ga., January 4, 1910.

945,693. Process of *Preserving Wood.* Justin Chateau and Jules Merklen, Paris, France. January 4, 1910.

945,711. *Oil Mixture.* John J. Fink, Washington, D. C., January 4, 1910.

945,843 Composition for *Coating Metals.* John B. Higley and Thomas F. Ryan, Eddystone, Pa., January 11, 1910.

945,926. Smelting *Sulphur Ores.* Richard Fleming, Swampscott, Mass. January 11, 1910.

945,948. Method of Process of Making *Artificial-Stone* or Plaster Columns. Albert G. Higgins, Kansas City, Mo., January 11, 1910.

945,954. Method of *Blacking Heated Iron.* George H. Johnson, Paxton, Mass., January 11, 1910.

946,294. Method of Making *Horny Nitrocellulose Bodies.* Vezio Vender, Milan, Italy, January 11, 1910.

946,360. Treatment of *Iron or Steel.* William R. Hodgkinson, Blackheath, England, January 11, 1910.

946,127. Process for Manufacturing *Ammonia.* Frederick W. Frerichs, St. Louis, Mo., January 11, 1910.

946,432. Method of Manufacturing *Carbide* and Products of Same. Herman L. Hartenstein, Constantine, Mich., January 11, 1910.

The process comprises producing a fused body of carbide and mixing therewith hardened particles of carbide, the mixture being stirred during the solidification of said fused body.

946,459. Finishing *Galvanized Sheet Metal.* Alexander Niedringhaus, St. Louis, Mo., January 11, 1910.

946,511. Method of Manufacturing *Carbide.* Herman L. Hartenstein, Constantine, Mich., January 11, 1910.

946,529. Method of Making *Durable Solutions of Peroxide of Hydrogen.* Joseph Arndts, Paderborn, Germany, January 18, 1910.

946,551. Process of Producing *Powdered Metallic Tungsten* or Other Hexavalent High-fusing-point Metals. Wilhelm Majert, Berlin, Germany, January 18, 1910.

This is a process of producing powdered metallic tungsten for incandescent filaments which consists in incorporating approximately five hundred parts by weight of finely powdered anhydrous sodium paratungstate with thirty-five parts of lamp black, in agitating and heating the same in an atmosphere of reducing gas comprising hydrogen to form metallic tungsten and incorporated tungstate and in dissolving out the sodium tungstate.

946,903. Electrolyte and Method of *Electrodepositing Copper.* Edward F. Kern, Knoxville, Tenn., January 18, 1910.

This is a process of electrodepositing copper, which consists in electrolyzing a solution containing fluo-silicate.

947,027. Process for *Lustering Silk Threads.* Edward Pohl, New York, N. Y., January 18, 1910.

947,031. Method of *Utilizing Steel-Scrap.* John P. W. Beekman, Parnassus, Pa., January 18, 1910.

947,067. Method of *Treating Nickel-Copper Alloys.* John F. Thompson, Bayonne, N. J., January 18, 1910.

The method consists in pickling nickel copper alloys by treating them with an acid solution containing a ferric iron salt.

947,078. Process of Manufacturing *Lactic Acid.* Wilhelm Klapproth, Nieder-Ingelheim-on-the-Rhine, Germany, January 18, 1910.

947,169. *Art of Tanning.* Frank Van Voorhis, Finleyville, Pa., January 18, 1910.

947,248. Alloy for Making *Car Wheels.* William Q. Lobdell, Wilmington, Del., January 25, 1910.

947,263. *Cast Metal.* Robert C. Totten, Pittsburg, Pa., January 25, 1910.

947,399. Process for the Preparation of *Zinc Oxide* for Reduction. Herman Pape, Hamburg, Germany, January 25, 1910.

947,400. Manufacture of *Fuel.* Thomas Parker, Wednesfield, England, January 25, 1910.

947,420. *Bath for Extracting Products from Wood.* Frederick Pope, Mount Pleasant, Ga., January 25, 1910.

947,433. Process of *Tanning.* Joseph M. Brown, Austin, Ark., January 25, 1910.

947,439. Art of *Treating Metal and Other Tubes or Rods.* Edwin T. Greenfield, Kiamesha, N. Y., January 25, 1910.

947,448. Process of *Reducing Iron Ores.* Charles B. Morgan, Oakland, Cal., January 25, 1910.

947,457. Process for the Continuous *Manufacture of Pellicles.* Marius Tatignier and Henry Pervilhac, Lyon, France, January 25, 1910.

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THE COMPARATIVE EXAMINATION OF MOLDING SANDS.*

By J. SHAW.

It will be well, first of all, to consider the ideal qualities of sand; it should be refractory, porous, strong and of a correct-sized grain.

REFRACTORINESS: This quality is determined by the amount of free silica and the purity of the clay. The higher the percentage of free silica and the purer the clay, the higher the refractory power of the sand. Other things being equal, the larger the size of the grains of free silica, the greater the heat-resisting power. All other ingredients in sand, except free silica and pure clay, tend to reduce its refractory nature.

POROSITY: With porosity I have classed permeability; but, of course, there is a distinct difference. By porosity is meant the amount of pore space a sand contains in a given area; by permeability, the freedom with which a gas can travel through the same area of sand. Two sands may have equal pore space, and yet one may be less permeable than the other. The porosity of the sand determines the amount of venting necessary in a mold, and depends on the proportion of free silica to the clay, the size and shape of the free silica grains, and the condition of the clay.

Generally speaking, the greater percentage of free silica, the greater the porosity of the sand, as the grains of this ingredient are comparatively large. The grains should be kept as large as is compatible with obtaining a fine skin on the casting. As free silica has no coherence, the percentage is limited by the clay needed to give the necessary bond.

TABLE A. RIES' CHARACTERISTICS OF VARIOUS SANDS.

	No. 1.	No. 2.	No. 3.	No. 4.
Silica	66.12	70.24	70.36	90.00
Alumina	16.54	16.62	9.36	4.50
Ferric oxide	4.46	3.94	3.18	1.44
Lime	0.40	0.08	0.44	0.10
Magnesia	0.22	0.09	0.27	0.10
Potash	2.67	1.41	2.19	Trace
Soda	0.35	0.74	1.54	Trace
Titanic oxide	0.14	0.46	0.34	0.70
Water	4.90	4.16	2.02	3.04
Moisture	4.15	2.42	0.74	——

*From a paper presented before the Birmingham Branch of the British Foundrymen's Association, March 12, 1910.

According to the investigations of King, if the grains are angular and of approximately the same size, the pore space for any given size is increased, because angular particles will not pack so well. A sand containing comparatively fine grains of a uniform size will be more porous than a sand composed of coarse and fine particles.

TABLE B. FIELD'S COMPARISON OF SAND ANALYSES.

Ultimate analyses.		Rational analyses.	
		Sharp Molding Sand.	
SiO_2	80.66	Quartz substance	67.85
Al_2O_3	9.30	Clay, substance + iron oxide	22.03
Fe_2O_3	4.53	Clay, substance less iron oxide	17.50
		Feldspar	10.12
		Strong Molding Sand.	
SiO_2	77.22	Quartz substance	64.66
Al_2O_3	9.26	Clay, substance + iron oxide	28.66
Fe_2O_3	5.56	Clay, substance less iron oxide	24.50
		Feldspar	7.28

STRENGTH: The strength of a sand depends, to a great extent, on the clay contents, but the purity of the clay, the shape of the free silica particles and good mixing are other factors. As already stated, the smaller the amount of clay, the more porous and refractory will the sand be. It therefore follows that, where possible, the quantity should be kept as low as the weight of the casting will allow.

TABLE C. FIELD'S SUGGESTION FOR A GOOD MOLDING SAND.

	Per cent.
Total silica	75 to 85
Alumina	7 to 10
Lime below	2.0
Alkalies below	0.5
Iron oxide below	6.0

The purity of the clay is important, because it takes less to give the necessary bond, and the impurities are the ingredients that fuse easily and thereby reduce both refractoriness and porosity.

This point will be further dealt with under chemical analysis. Sands with grains having rough angular shapes are stronger than those with smooth surfaces, because they interlock.

That good mixing, either by hand or machine, adds

considerably to the strength of a sand is well known. Outerbridge tested this by placing test bars of sand 6 by 1 by 1 inch, made under uniform conditions of pressure and dampness, on a smooth metal plate with sharp square edges, and by gently pushing the bars over the edge of the plate until they broke; he obtained some idea of the strength by measuring the overhang. A sand mixed and tempered by hand with a spade gave an overhang of less than 2 inches, but when riddled a dozen times the test bars overhung about three inches before they broke.

Size of Grains: The correct size of grain has been dealt with to some extent under the previous headings. A sand should be as fine as possible, to give a good skin to the casting, but the finer the sand, the more easily is it fused. Equal size grains give a porous sand, and a correct proportion of large and small grains gives a strong sand.

We have now some idea of the qualities we need in the sand for our purpose. Is it possible to formulate a set of standards that any sand can be compared with? It was with this idea that I asked several members to send a sample of the sand they were using, and at the same time to answer a number of questions as to treatment, size and shape of castings made, etc. But I must confess that owing to the personal element, sand differing in many respects gave equally good results. When a molder enters a shop, he after a time adapts himself to any new conditions, and by inquiry and practice overcomes difficulties in the sand which may vary in many respects from the one he has been used to.

The usual tests for sands are chemical analysis, sieve test, and microscopic examination.

With regard to chemical analysis, I should like to emphasize two points. Many people understand that when an analysis of sand is given showing, say, 80 per cent of silica, free silica is meant, forgetting that a proportion is united with the alumina. It is for this reason I have used the term "free silica" previously. As already shown, this ingredient gives refractoriness, porosity, grain and low shrinkage to the sand, but has no bonding properties of its own.

In the same way a misunderstanding exists as regards alumina. To say a sand contains 9 per cent alumina, does not mean it has 9 per cent bond and the remaining 91 per cent free silica, as clay, or hydrated silicate of alumina, to give it its chemical name, consists of 46.4 per cent silica, 39.7 per cent alumina, and 13.9 per cent combined water, the latter giving the plastic properties to the clay. The bond of a molding sand is pure clay, but it is generally mixed with impurities which weaken its bonding power.

Clay is formed by the decomposition of felspars. These are rocks containing silicate of alumina, together with silicates of the alkalies. After the rocks are decomposed, more or less of the alkalies are washed out by nature's agencies, the amount remaining determining the purity of the clay and hence its value as a refractory and bonding medium. The purity of the clay determines the amount necessary to give a sand its correct bonding strength.

TABLE D. COCHRANE'S CHEMICAL ANALYSIS AND SIEVE TESTS OF ERITH SAND.

Chemical analysis.		Sieve Tests. Weak.	Medium.	Strong.
SiO_2 ..... 88.25	30	0.400	0.192	1.320
Al_2O_3 ..... 7.70	60	0.868	0.840	4.556
Fe_2O_3 ..... 2.50	90	0.560	0.280	1.220
CaO 0.72	150	67.088	38.876	14.080
MgO 0.58	150+	30.468	58.088	76.020
Loss 1.00		99.384	98.275	97.196

From the above it is clear that the percentage of clay should not be figured from the percentage of alumina present, as all sands contain felspars, which in turn contain alumina. *This alumina in the felspar has absolutely no bonding power.*

As already stated, felspars are silicates of alumina, combined with silicates of the alkalies, and are present in all molding sands. The amount should be as low as possible, as they tend to flux the sand under moderate temperature.

Oxide of iron is present in all molding sands, giving it its red or yellow color. It may be united with the bond as an impurity, or it may form part of the free silica. In any case, it lowers the fusing point.

Lime is generally found in molding sands; it makes the sand fusible, and the lower it is the better.

While it is generally conceded that chemical analysis of sand is of less importance than physical properties, much information may be gained if applied rightly. Its use at present is to check the impurities and to see that the sand is chemically up to sample.

TABLE E. ANALYSES OF NORTH MIDLAND SAND.

Ultimate Analysis.		Rational Analysis.		Sieve Test.	
SiO_2	88.00	Quartz	66.25	30	0.008
Al_2O_3	7.20	Clay + Fe_2O_3	12.00	60	1.280
Fe_2O_3	1.20	Clay — Fe_2O_3	10.80	90	29.308
CaO	0.20	Felspar	21.75	150	54.600
				150+	14.236
					99.432

Professor Ries points out there is no relation between the bonding power and plasticity, and the percentage of alumina present, as is generally claimed. He gives the analyses in Table A to show this, No. 1 being a coarse-grained gravelly sand, and No. 2 a fairly plastic loam.

Other examples are given in Nos. 3 and 4, Table A; No. 3 is a well known molding sand for plate work, while No. 4 is a sandy brick clay of sufficient plasticity and cohesiveness to be used for brick manufacture. Judging from the analysis, it would be thought that

No. 3 was more plastic because of the lower silica and higher alumina contents.

The same author also states, that there is no relation between the chemical composition and the use to which

TABLE F. ANALYSES OF MANSFIELD SANDS.

Ultimate Analysis.	Sieve Test.	Fine.	Coarse.
SiO_2 ..... 84.26	30	0.388	0.156
Al_2O_3 ..... 6.70	60	0.928	2.632
Fe_2O_3 ..... 3.50	90	3.388	15.128
CaO 0.19	150	39.160	60.932
MgO 0.68	150+	54.268	19.980
		98.132	98.828

the sand is put, and he gives a series of analyses, where sands totally different in composition are used for the same class of work.

Whether the method advocated by Field (to whom we are indebted for much information) will give a satisfactory solution, I have not had time to test thoroughly. Certainly it offers an explanation to analyses like those just mentioned. He suggests that what is known as "rational analysis" will give a more correct idea of the constituents of a molding sand than does ultimate analysis. The former method separates the sand into three substances, viz., quartz substance, clay substance, and felspars, and he gives two examples in Table B of a sharp and strong molding sand that lend point to his theory.

The same author gives in Table C what he considers the ultimate analysis of a good molding sand should be.

The total percentage of iron oxide, lime and alkalies, or the total fluxing agencies, should not exceed 7 per cent. In high-grade sand for heavy work they should not be more than 5 or 6 per cent. Mechanical analysis, or sieve testing, of sand is valuable because it gives you an idea of the texture of the sand and indirectly of the permeability and refractoriness. Unfortunately, I found no two authors followed the same mode of procedure, and I think it would be a good opening for some member of our association, who has time and appliances, to draw up a fixed routine so that results could be compared.

The first to deal with grain separation, that I found, was Morse, so far back as December, 1893. He simply divided his sample into coarse sand, fine sand, very fine sand, and clay.

Scott used sieves of 20, 40, 60, 80, and 100 mesh to separate his sand into different size grains. He took 10 grams of the dried sand, placed it with 10 steel balls 7/16 in. diameter in the 100 mesh sieve and shook it with a circular motion for one minute. The sand passing through was weighed and credited to the 100 mesh sieve. The sand remaining on the sieve, together with the balls, was emptied on the 80 mesh sieve; the opera-

TABLE G. ENGLISH SAND SAMPLES ANALYZED.

ULTIMATE ANALYSES.

	Stourbridge.	Wordsley.	Kidderminster.	Tettenhall.	Whitwick.	Moxley (Red).	Moxley (Loam).	Icknield.
SiO_2	82.070	81.10	83.60	84.1	84.5	86.7	88.2	85.6
Al_2O_3	5.070	5.63	6.26	6.2	6.8	5.4	5.5	5.7
FeO_3	4.960	6.20	4.10	....	....	....	....	....
CaO	0.550	0.70	0.66	....	....	....	....	....
MgO	1.170	1.01	0.51	9.7	8.7	7.9	6.3	8.7
K_2O	2.480	2.66	.....	....	....	....	....	....
Na_2O	0.546	0.50	.....	....	....	....	....	....
Loss	2.000	2.70	.....	....	....	....	....	....

Kidderminster, per P. Longmuir. The last five analyses per J. R. Cooke, Wolverhampton.

RATIONAL ANALYSES.

	Stourbridge.	Wordsley.
Quartz substance	61.536	57.59
Clay substance	11.210	14.46
Felspar	22.300	21.75
(Analyses by E. Taylor).		

SIEVE TEST.

	Stourbridge.	Wolverhampton.	Bl. M.	Kidderminster.
30	0.496	0.548	0.400	0.08
60	6.416	1.328	7.092	1.608
90	17.820	13.500	23.548	16.092
150	49.896	47.696	46.348	55.84
150+	24.708	35.040	20.640	20.84

tion repeated, and so on, down to the 20 mesh sieve. Field's method is somewhat similar.

Professor Ries tackled the problem entirely differently. He took 50 grams of the sand and placed it in an 8 oz. bottle half filled with water. This mixture was put in a shaker for four hours, after which it was washed through a set of 20, 40, 60, 80 and 100 mesh sieves. The sand retained on each was dried and weighed. That which passed through the 100 mesh was caught in a jar. When all the water and suspended matter had been run through the sieves, the contents of the jar was stirred up, and after standing 45 seconds the water with suspended clay and fine silt were decanted off. More water was added, the contents of the jar again stirred, and the decantation re-

peated. In this way two sizes were obtained. That which remained in suspension he termed the clay, and that which settled was indicated as 100+, and more of it was retainable on a 150-mesh sieve.

Personally I tried both methods, but could not get even approximate results. With Scott's method, much depended on the condition of the dried sand, and more on the velocity and number of times the sieves were shaken. After making about 50 trials from the same kind of sand, I tried Professor Ries' wet method. This gave far better results, but with my limited time and lack of appliances took too long to get through the samples sent.

The method adopted at last was as follows: Using 30, 60, 90 mesh sieves (because these sizes are English standards, and any one can get a set for 3s. 6d.), I added a 150 mesh sieve so as to divide the finest portion. After rolling the dried sand under a light wooden ruler, to break up the compound grains, I weighed 25 grams, placing it with 10 steel balls 5/16 in. diameter on the 30 mesh sieve, and shook it till practically no more would go through. The portion left was credited to the 30 mesh. Placing the balls, together with the sand which had passed through the sieves in the first operation, on the 60-mesh sieve, the same routine was followed, and so on till the sample was divided into five distinct sizes of grains, each portion being weighed and credited to the size of sieve it rested on. That which passed through the 150 sieve was called 150+. After doing about 50 trials from the large sample the results were found as near as could be expected.

Coming now to the samples so kindly sent by various members, the chemical analyses of most were obtained. All were submitted to the sieve test and microscopic examination.

To give a graphical idea of the differences in the samples, I obtained a number of screw-topped bottles, all about the same size. Taking five for each sample, the contents of each sieve was emptied into a bottle and the stopper marked with the mesh of the sieve and the locality of the sand. The five bottles were gummed on to a piece of cardboard, together with the answers to the questions sent.

Starting in the North with samples from three prominent firms, all of whom use Erith sand; this is the finest grained sand sent in and notwithstanding its high silica content has a tendency to scab. I am indebted to Mr. Mayer for the following particulars: The sand is brought as ballast in boats on the return journey, and is sold in three grades. The weak top sand with least alumina, the medium quality with more alumina, and the strong, from the bottom of the pit, with most alumina, the last, of course, being used for dry sand and loam. The texture of this sand is so fine that it requires no mechanical treatment and is mixed with coal dust and in some cases a proportion of old sand, riddled and mixed ready for use.

The chemical analysis (kindly sent by D. Cochrane) was as in Table D, but, of course, the alumina content will vary according to grade. It will be noticed that the quantity in 150+ increases in bulk as the alumina increases.

From Lancashire three samples were also received, and curiously two of these were the coarsest grained in the sands examined; but that clean fine work can be made from them any one who has seen castings at the Lancashire and Yorkshire Railway shops can testify. In both cases the sand is well milled to give it strength. The sieve test was 30, 0.800; 60, 41.140; 90, 39.056; 150, 13.020, and 150+, 4.580. The total being 98.596.

The next section came from firms in the North Midlands, from pits at Worksop (2), Mansfield (3), Kirby-in-Ashfield (1). Mr. Pilkington gave the ultimate analysis and Mr. Houghton the rational analysis of their Worksop sand as in Table E.

The other sample from Worksop either was from another pit or a different strata, as the sieve test showed the sand to be considerably coarser, and it was used on heavier work without skin drying. Mansfield also had two types of sand at least—a fine one for brass and light castings, and a coarser grained for heavier work. The analysis is given in Table F.

The sample from Kirby-in-Ashfield was very similar in sieve test to Worksop.

From the South, Mr. Ellis sent me a sample of a local Southampton sand he uses. Not unlike Erith in color (but darker), it is much coarser in grain, and castings up to 2 tons are made without skin-drying; the sand is not ground but mixed and riddled. The sieve test is 30, 0.200; 60, 1.400; 90, 14.80; 150, 69.200, and 150+, 13.320, giving a total of 98.920.

Taking our own district last, seven samples were sent in (including one from a firm at Cardiff, who obtained their sand from Stourbridge). The analyses and sieve tests are presented in Table G.

The sample from Wolverhampton was used on small work, and no doubt a coarser grade is sent out. Three firms simply add coal dust, cut, mix and put through a centrifugal mixer. Two grind in a mill. One both riddles and grinds and the last simply mixes, treads and riddles. The proportion of coal dust varies from 1 to 6 to 1 to 10. Old sand used varies from nil to 65 per cent.

Coming to microscopic examination, I found most of the grains of sand with worn edges, the Erith being the most angular. Geologists tell us the sand beds from which we in the Midlands get our material once formed the bottom of a huge lake, and was deposited layer upon layer, much as the bottom of Lake Geneva is being made today—hence the rounded appearance of the grains.

While no hard and fast rules can be laid down, a knowledge of the chemical and physical properties of your sand can but be helpful. That an artificial sand can be prepared, superior to any natural sand, and specially fitted for particular classes of work, I have proved, but the cost puts it out of the market.

REGULATION OF THE PERCENTAGE OF CARBON DIOXIDE IN FURNACE GASES.*

E. A. BARNES.

Much has been written and published in the last year or so on the subject of CO_2 in its relation to boiler room practice, the writers having given much valuable information in explaination of CO_2, but little having been said of its practical applicaton and the pitfalls attendant on its introduction into existing boiler rooms.

In order to meet with even moderate success, the firemen who are to do the work, as well as the engineer and superintendent of the plant, must be in harmony with the arrangement. It often happens that the introduction of CO_2 economy methods in a power plant is turned over to a technically educated engineer who, through lack of practical experience, commences by calling for unnecessary refinements, especially with relation to sampling tubes in the boilers.

He is also very insistent on taking samples from different passes in the boiler, and goes about the work as though the research and history of the CO_2 percentage in the boiler itself was the thing to be arrived at; this, not being understood in the operating department, at once leads to complication and lack of co-operation.

The primary object in introducing CO_2 analysis in a boiler room is to save a percentage of the fuel by scientific firing in place of the haphazard, unscientific firing that has been in use for so long. Tables prepared up to date show that this can be done, and the best way to accomplish the result is to have the simplest apparatus possible, and that which can be thoroughly understood and operated by the boiler room force.

As firing under conditions that make for the greatest economy is much more uncomfortable for the fireman by reason of the greater amount of heat radiated from the boiler fronts, fire doors, etc., some form of extra compensation, preferably in the form of a sliding scale premium system based on a fair allowance, must be worked out.

In the opinion of the writer the best place to introduce the sampling tube is at about the center of the damper box or main flue breeching leading to the stack. This sampling tube should be of ¾ in. or 1 in. common gas pipe, from 3 ft. to 6 ft. long, open at the ends and with a ⅛ in. slot through practically its entire length.

The pipe leading from the sampling tube to the rest of the apparatus need not be over ⅛ in. standard pipe, securely and permanently fastened to the boiler walls and equipped at the lower end with a suitable stop cock so that connection by means of a rubber hose can be made to the testing apparatus.

A number of sampling devices have been designed, but the integrating bottle is the simplest, being nothing more than an inverted bottle holding five gallons of water, and provided with a suitable drain and pinch cock so arranged that the flow of water from the bottle can be regulated to continue for a certain predetermined period. The subsiding of the water from a partial vacuum and sucks in the products of combustion from the sampling tubes in the boiler. This bottle is removed periodically and gases therein tested with the regular Orsat apparatus, the average CO_2 percentage through this period being thus arrived at.

There is another instrument called the econometer, in which the weight of flue gas as compared with that of the atmospheric air is constantly indicated on a scale.

The inverted bell sampler, as its name indicates, is a glass bell inverted in a water-sealed glass chamber. This is designed to operate by clock work and is suitably balanced. The rate at which the bell is withdrawn from the water-sealed chamber depends, of course, on the adjustment of the clock and the duration of time over which the samples are to be taken.

There is also the automatic motor-driven Orsat with recording adjustments, of which there are several designs on the market.

All the latter automatic instruments require a great deal of supervision, and unless kept in thorough working order, their indications cannot be depended on. As before stated, the simplest form of apparatus appeals most strongly to the average plant. Various conditions of induced draft, forced draft, natural draft, automatic stokers, hand firing, etc., all introduce factors that tend to change the results and call for different handling in different installations. In this article we will consider only hand fired boilers having induced draft.

In a hypothetical case, we will assume that the CO_2 averages about 11 or 12 per cent, and things go along very nicely for months, when all at once it is called to our attention that certain boilers are not holding up their percentage. Investigation is made, and it is found that the fireman has the dampers shut down and everything apparently in good condition. The boiler brick work is examined and it is discovered that there are innumerable cracks in the brick work around the cleanout doors and on top of the boiler where the domes and drums protrude. As soon as these are cemented up with suitable cement the CO_2 percentage at once goes back to the normal condition. It is the excess of air entering in through these leaks that has caused the trouble. Without the telltale CO_2 percentage showing, this waste would go on unchecked indefinitely.

Where a number of boilers in the same plant are being fired by men on a premium system, it is necessary to have some form of counting apparatus for each boiler or set of boilers handled by individual firemen. If this is not done, the wise firemen will keep their dampers closed and burn a very light fire and get a high percentage of CO_2 during the shift, but will consume little coal. The other fellows, who are shoveling

*General Electric Review, March, 1910.

in continuously, have their doors open and not only their CO_2 percentage goes down, but they are doing all the work and not getting as much pay as the men who are holding back. The counters are intended to indicate the amount of fuel fired per man.

Another point that is well to bear in mind is that the boiler settings as specified by the boiler makers in many cases are not properly worked out for the excessive heat that has to be withstood inside of the fire box and boiler settings under the new conditions. It has been my experience that nothing but the highest grade of fire brick should be laid up in courses of two stretches and one header alternately. It is also very desirable to have every fourth header brick specially long, say 18 in., so that it not only binds the inner skin of high grade brick, but hangs over and is toothed into the low grade brick that usually constituted the intermediate filling.

If these precautions are not taken the excessive heat will warp and burn away the inner lining, causing it to bulge and crack, and there is danger of letting down the main arch. These precautions may seem unnecessary, but if results are wanted they must be carried out.

With regard to the arches, they must also be built of the highest grade brick, and should be laid out in the drafting room full size—so many straight brick and so many wedge brick—so that the masons who do the work will lay them up in this way. If this is not done, the arch will fail because the masons will use straight brick clipped into position and fill in the top crown with a lot of spalls and fire clay mortar.

I have mentioned above that different plants require different treatment, and I know of one plant in particular in which chain grates are used, where the clearance allowed around the chains and back of the chains is so great that enormous quantities of excess air enter at these points, and a low percentage of CO_2 results.

Where chain grates and automatic stokers are employed all clearances must be cut down so as to reduce to the lowest possible percentage the amount of air that does not pass through the fuel bed.

Among other important things that should be found in an up-to-date fire room are colored glasses through which the firemen can examine their fires. It is only by firing often and light, and covering over the "rat holes" and preventing the ingress of excess air that the best results can be attained. It is also very necessary that the draft be cut down as much as possible.

In Japan there is in use a copper furnace which consists of a hole in the ground about 2 ft. in diameter and 2 ft. deep, lined with fire clay mixed with charcoal dust. The ore and charcoal are charged in layers, and the blast is supplied by means of a hand bellows, being directed upon the center of the charge. A charge is blown to matte in about five hours and then re-smelted as many times as necessary to produce metal.

ELECTROLYTIC MAGNESIUM.

The usual method of producing metallic magnesium electrolytically is to pass a current through fused magnesium chloride, using some potassium chloride as flux. The specific gravity of this electrolyte is so near that of magnesium that the metal liberated will only under certain conditions and at certain temperatures fall to the bottom of the bath. G. O. Seward and F. von Kugelgen describe in U. S. patent 931,092 a method of overcoming this physical difficulty. Instead of seeking to sink the magnesium they introduce a compound of higher specific gravity into the bath so that the magnesium shall easily float. The substance they prefer is barium chloride, and the constitution of the bath they use is 5 parts of magnesium chloride, 5 parts of potassium chloride and 3½ parts of barium chloride. The magnesium liberated floats in this mixture and can be easily removed.

MANUFACTURE OF ALUMINA.

The McCulloch process (U. S. Pat. No. 941,709) for the production of alumina is as follows: A liquor of approximately the proportions Al_2O_3, 75 to 80 grams per liter; Na_2CO_3, 40 to 50 grams; Na_2O combined with Al_2O_3, reckoned as NaOH, 105 to 115 grams; SiO_2, 0.15 to 0.25 gram, is placed in an agitator which is preferably a long, cylindrical steel tank. The liquor is then stirred by paddles, and carbon dioxide passed over it, which reacts with the sodium aluminate, forming Na_2CO_3 and aluminum hydrate, until the alumina present in solution has been reduced to 5 to 10 grams per liter. The composition of the liquor is now about Al_2O_3, 5 to 15 grams per liter; Na_2O combined with Al_2O_3 and reckoned as NaOH, 10 to 20 grams; SiO_2, 0.10 to 0.20 gram; Na_2CO_3, 185 to 195 grams.

Silica, as well as alumina, is precipitated by the carbon dioxide, but not in the same ratio. From the silica content of the liquor, it can be determined just when to stop the precipitation to obtain any desired degree of purity from the silica. The separation of the alumina and silica is the important feature of the process.

Lipowitz metal has a silvery white color and a lustre like polished silver and it can be bent short, hammered and worked in the lathe. It is used for making casts of small animals and insects, and is a suitable solder for tin, lead and Britannia metals. Woods metal is like platinum in color and is malleable. A single coat of cadmium yellow paint is transparent, and as the pigment is quite expensive it is customary to use a coat of cadmium-yellow over several coats of chrome-yellow, the former serving as a protective coating for the body of the latter. This plan is adopted by railway and street car companies which finish their passenger coaches in yellow. Chrome yellow is apt to fade and darken under the action of sulphur gases.

THE PLANT.

A COMMERCIAL FUEL-BRIQUETTE PLANT.*

By W. H. BLAUVELT.

Engineer, Semet-Solvay Co.

The subject of fuel-briquetting has attracted much attention on the part of engineers and investors for the past 15 or 20 years, and especially in recent years, during which a number of plants have been built with more or less commercial and technical success. Our technical literature contains numerous descriptions of certain processes, and discussions of the industry in general.

The purpose of the present paper is to describe the briquette plant of the Solvay Process Co. and the Semet-Solvay Co. at Detroit, Mich., which, after a period of long and costly evolution, is now operating satisfactorily on a commercial basis.

In planning for the Detroit plant the domestic market appeared the most promising, and therefore a rotary type of press was selected which would produce small briquettes, or eggettes, each of about 2-oz. weight.

The raw materials used are coke-breeze from an adjacent coke oven plant, and dry non-coking coal from either the Hocking Valley or the Jackson Hill districts. These materials are used in equal proportions, by weight, mixed with from 8 to 9 per cent of the binder. Coke-breeze appears to require somewhat more binder than coal; perhaps on account of its porosity, which allows the binder to be absorbed into the cell structure without useful effect. Probably further experince will result in reducing the percentage of binder used. Coal tar pitch was selected as the binder.

Two processes are in general use, one using soft pitch, the other hard. In the former the pitch is melted by steam heat, or in an oven fired with coal or other fuel, and mixed with the solid fuel while liquid, while in the latter process the pitch is made hard enough to permit of its being ground to a fine powder. In practice this latter means that, adopting the usual tar-distiller's test, the pitch should be somewhat harder than can be chewed in the mouth without fracture after the pitch has been permitted to reach the temperature of the mouth. Unfortunately, no more scientific method of testing the hardness of pitch has been agreed upon as yet. The whole subject is in a rather chaotic stage, so the old tar-distiller's chewing-test is still largely employed.

*Abstracted from a paper read before the Pittsburg meeting of the Am. Inst. Mg. Engrs.

The hard pitch method was selected for the Detroit plant, partly because the soft pitch methods are always a source of danger from fire, but mainly because it is believed that the hard pitch method is the one which should be developed, with a view to obtaining the pitch at the lowest price delivered at the briquette plant. Hard pitch is more easily transported, either in very cheap packages, or, in cold weather, in bulk, and it can be produced at lower cost, since a larger portion of the more valuable oils contained in the original tar have been removed. Possibly the hard pitch method requires a slightly larger quantity of binder with some coals, but the lower cost at which it can be manufactured more than offsets this objection, and it also has the advantage of producing less smoke in combustion.

The process as at present conducted is essentially as follows: The coal is unloaded into a track hopper and elevated to the coal bin. As slack coal is always used, no preliminary crushing is necessary. The coke breeze usually contains considerable moisture, so in order to maintain constant conditions the breeze is dried in a rotary drier before being elevated to its storage bin. The coal and coke are brought together from the bins into a measuring machine, which delivers the two materials in any desired proportion to a hammer mill of the Jeffrey or Williams type, in which the mixture is finely ground. The pitch which meets the coal and coke in this mill is brought from the pitch storage shed by a pitchman, who breaks it into pieces of convenient size for feeding to the pitch cracker. This cracker consists of a pair of rolls, 16 in. in diameter and 12 in. face, with small V-shaped corrugations, running at a speed of 85 r. p. m. These rolls crush the pitch to about 3/8 in. in diameter, and give no trouble unless the pitch employed is too soft to retain its brittleness at the temperature of the atmosphere. The crushed pitch falls from the rolls into a small hopper, from which a screw conveyor, which acts as a measuring machine, delivers a definite quantity of pitch on to a small belt conveyor which in turn discharges the pitch into the mouth of the hammer mill, as above stated.

By grinding the coal, coke, and pitch all together in the hammer mill the three materials are thoroughly mixed, and opportunity is given for each particle of the coal and coke to receive a coating of pitch powder, which, of course, is the theoretical condition to be striven for. Practice has shown that in pulverizing coke-breeze the wear on the mill hammers is too great, and it is planned to install a small pair of chilled-iron

rolls for pulverizing the coke, leaving the hammer mill for the coal and pitch. The pulverized coke, coal, and pitch will be delivered direct to an elevator boot, which raises the mixture to the top of the building. From this elevator the mixture is conveyed in a rotary conveyor, in which the different ingredients are thoroughly mixed, to the rotary heater, consisting of a cylinder 40 in. in diameter and 21 ft. long, set at a slight inclination. By the revolution of this cylinder the mixture passes from the upper to the lower end and is thoroughly mixed thereby. The cylinder is also heated to a temperature of about 80° C. by superheated steam introduced through a perforated pipe extending the length of the cylinder. This steam is superheated by the waste heat from the coke-breeze drier. In this manner the several components have been accurately and uniformly proportioned, pulverized, mixed, and heated to a controlled temperature; also, a small quantity of water has been introduced, which is desirable to insure a pliant and readily moldable material for the press. In some processes a vertical cylinder with stirrers is employed instead of a horizontal rotating cylinder, the mix being heated with superheated steam in a similar way.

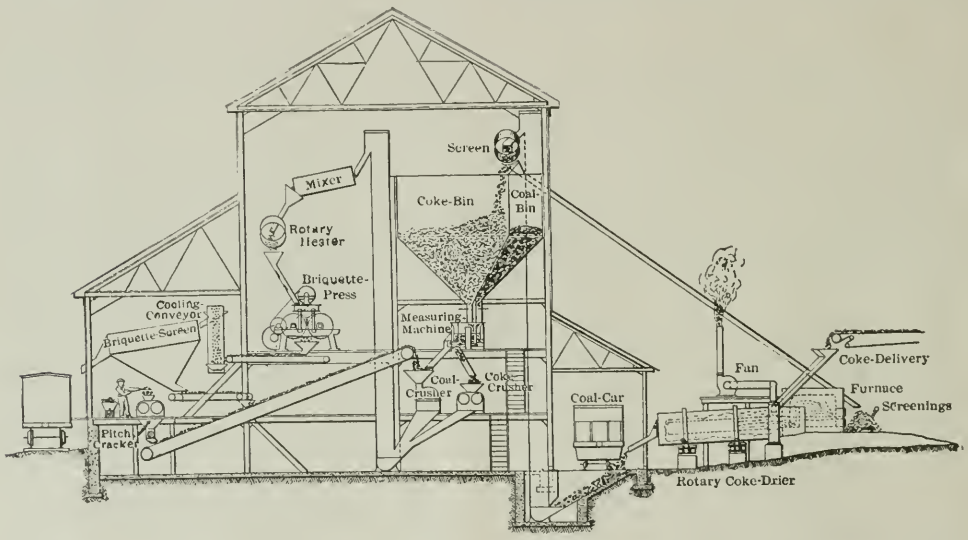


Fig. 1—Diagram Showing Arrangement of Fuel-Briquette Plant, Solvay Process Co. and Sement-Solvay Co.

From the mixing cylinder the material is delivered by a short chute to the feed box over the rotary press. The press used at this plant is of French manufacture and of the standard Belgian type. It consists of a heavy frame supporting two rolls, each of which carries in the middle a gear having 7-in. face and 2.5-in. pitch, and on each side of the gear a steel tire, 5.25 in. wide on the face by 2.5 in. thick. These gears and tires are accurately fitted on to the drum or roll, and keyed and bolted to place. The faces of the tires are hollowed out or cupped into recesses about 2.25 in. long and 1⅞ in. wide. There are three rows of these cups, arranged as closely as possible, so that each tire contains 207 cups. The rolls are accurately registered, so that the cuppings in the adjacent tires shall produce the egg-shaped briquette, the shape and dimensions of the cuppings determining the form and weight of the briquettes. Provision is made for turning up the faces of these steel tires as they wear and for cutting out the cups, so that the life of the tires may be thereby prolonged. It is found that the wear is much greater with coke-breeze than with coal alone, and it is proposed to substitute rolls with a chilled-iron face in place of the steel. It has been found in our experiments that even the alloy steels, especially designed to resist wear, are not as satisfactory as chilled cast iron. The cutting action of the sharp particles of coke wears the best manganese steel, for example, perhaps even more rapidly than ordinary tool steel.

Adjustments are provided on the frame of the press which allow the rolls to be brought together as the tires wear or are dressed down. The rolls are driven by means of a pinion engaging one of the pair of gears. The pinion shaft in turn is driven through gearing by a belted motor. The belt affords a convenient safeguard in case of foreign material getting between the rolls and blocking them. If a direct drive is used, carefully designed breaking pins are essential.

The mix which has been delivered into the feed box is constantly stirred therein by rotating paddles, and fed down to the rolls through two chutes, specially arranged with sides which may be moved in parallel, thereby controlling the feed of the mix to the rolls. It is essential to the production of uniform briquettes that, in addition to the mix being uniform in composition and temperature, the quantity delivered between the rolls must be accurately controlled since it is the resistance of the material itself which determines the

amount of pressure under which the briquette is produced.

From the press the briquettes fall on a conveyor belt and are delivered to a cooling conveyor outside of the building. This cooling conveyor is a slow-moving rubber belt of sufficient length to permit the briquettes to cool sufficiently so that the pitch will harden and given strength to the briquette to resist breakage as it passes through the screen and falls into the railroad car. At some plants the cooling conveyor is constructed of a woven wire belt, which would seem to be advantageous in that it gives greater access of air to all sides of the briquettes. When the briquettes have been sufficiently cooled to have acquired the necessary toughness, they are delivered from the cooling conveyor to a rotary screen, which separates out any fine material and knocks off any fins which may adhere to the briquette on account of wear of the rolls. From the rotary screen the briquettes fall into railroad cars for shipment, or into storage piles. A small conveyor returns the fine unbriquetted material and the fins to the plant and delivers it back to the hammer mill, so that it is pulverized and thoroughly mixed with the new material.

The capacity of this plant has not yet been fully developed. It has been brought up to 9 tons per hour, and it may reach 10. The main features of the plant are, however, arranged to have a capacity equal to the output of two presses, and it is the purpose, as the market develops, to add the second press. This addition would result in a very material reduction in the cost of operation, since the labor required will be but little more than at present, about two more men. The power required for operating the elevators, conveyors, etc., and the repairs on these parts of the plant will be but little more than at present when the tonnage has been doubled. Probably the power required and the wear on the pulverizing mills, presses, and some other parts will be more nearly in proportion to the tonnage. An examination of the costs given below, based on the output of one press and two presses, shows very clearly the effect of output on the cost of briquette manufacture.

Repeated readings have been made of the power consumed in the different parts of the plant, with the following average result:

Motor driving.	B.h.p.
Breeze conveyor to drier	1.50
Breeze drier and ventilating fan	2.85
Pulverizing mill	22.00
Elevator shafting and rotary mixer	10.00
Briquetting press	25.00
Total	61.35

The press motor also drives the cooling conveyor, rotary screen, pitch cracker, and conveyor.

The consumption of steam in the rotary heater and mixer depends partly upon the temperature of the atmosphere and partly upon the quantity of binder and its melting point. Tests at the Detroit plant, extending over a number of days, show a consumption of 206 lb. of steam per ton of briquettes produced. This result was during a period of somewhat slow operation. No tests have been made during a period of steady running at full speed, but the above steam consumption per ton of product would undoubtedly be decreased by a larger output. The superheating of the steam is desirable in order to maintain it in a dry state, and prevent the addition of too much water to the mix. The experiment was tried of heating the outside of the rotary mixer and heater with a gas flame, but the use of superheated steam seems to be more satisfactory.

The labor on a plant similar to the one described is approximately:

	Cost per hour.
1 foreman	$0.50
1 pressman	0.26
1 oiler, breeze-drier and conveyor man	0.18
1 pitchman	0.18
1 briquette loader	0.19
2 laborers, at 17 cts.	0.34
Total	$1.65

When producing 9 tons of briquettes per hour, the labor cost becomes 18.3 cts. Two presses would double the output, but would only require two more men at 18 cts., and a second pressman at 26 cts. per hour, which would bring the labor cost to 12.6 cts. per ton.

The use of coke-breeze increases the wear on all apparatus with which it comes in contact, but most especially on the briquetting rolls. The question to be determined in each case is whether the breeze can be obtained at a cost sufficiently low in comparison with coal to offset the increased repairs due to its use. In addition, coke-breeze has the advantage of being smokeless, so that its use reduces the smokiness of soft coal briquettes. The difference in cost of maintaining the briquetting rolls with and without coke-breeze is so great that two cost sheets are given below, which will illustrate the approximate cost of manufacturing briquettes under these two circumstances in a plant similar to that here described, producing 9 tons of briquettes per hour. If the plant were operated on the basis of the larger production obtained from two presses, it would be safe to estimate a reduction in these two costs, of say, 10 cts. per ton.

	Cost per ton using 50% breeze.	Ton of product using 100% coal.
Labor	$0.183	$0.183
Power, at 1.25 cts. per kw. hr.	0.072	0.072
Steam, 206 lbs., at 0.5 ct. per hp.-hr.	0.034	0.034
Breeze drier and super heater fuel	0.03	0.011
Miscellaneous supplies, oil, waste, lights and water	0.03	0.03
Repairs on rolls	0.191	0.035
Other repairs	0.05	0.035
Total	$0.60	$0.40

To obtain the total operating cost of a plant such as has been described, and operating under similar conditions, the cost of the pitch for binder and of the coal, coke-breeze, or other fuel used, must be added to these figures.

In order to have an illustration of such costs, let us assume that suitable slack coal can be obtained at $2, coke-breeze at $1, and pitch at $8 per ton, delivered at the plant. Since, as above pointed out, the use of breeze requires somewhat more binder, we will assume the use of 7.5 per cent binder with the coal and 9 per cent with the mixture of coal and breeze.

Cost of one ton of briquettes.	All coal.	Equal parts of coal and breeze.
0.455 ton coal, at $2	...	$0.91
0.925 ton coal, at $2	$1.85	
0.455 ton breeze, at $1	...	0.455
9 per cent pitch, at $8	...	0.72
7.5 per cent pitch, at $8	0.60	
Cost of briquetting, as above	0.40	0.60
Total	$2.85	$2.685

Many coals can be briquetted with less than the above quantities of pitch, and, of course, the costs of coal (and coke-breeze vary at every plant, but the substitution of local prices in the above tables will give approximately the cost of briquettes in a plant having about the capacity of the one described. In larger plants the cost of operation is less, and with briquettes of large size for industrial purposes the cost would be materially reduced.

In contemplating the erection of a plant, not only must a press be selected suited to the material to be treated and also to the kind of briquette demanded by the available market, but it must be remembered that a briquette plant includes much more than the mere press. To insure economical operation, the preparation and handling of the material must be carefully studied and planned for, and the whole combination of driers, bins, elevators, measuring machines, crushers, mixers, heaters, conveyors, etc., must all be combined with the press into a single effective and economical unit, which will insure a uniform proportioning of the materials, their thorough and intimate mixture, their heating to a sufficient and uniform temperature, and their delivery to and removal from the press at a constant and reliable rate. If the various units entering into a briquette plant are thus successfully combined with careful economy of power and convenient arrangement, so that the labor is maintained at a minimum, a briquette plant should be a reliable and assured source of profit in locations where a satisfactory raw material and market for the product obtain. While the processes are simple and easily understood, it is essential that the different conditions be rigidly maintained, and usually it is only after the pressman and other more important operatives have attained certain instinctive recognition of the conditions that the plant becomes thoroughly successful.

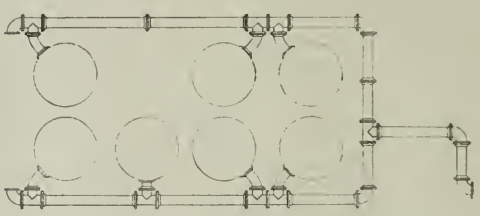
THE USE OF ALUMINUM FOR NON-CORROSIVE PURPOSES.*

By EDWARD K. DAVIS.

Superintendent Aluminum Company of America, Pittsburg, Pa.

Aluminum possesses the quality of resisting the corrosive action of many substances which affect copper, brass and bronze—among others, sulphates, nitrates, ammonia and organic acids. Manufacturing plants having occasion to handle any of these in solution are likely to obtain good results by the substitution of aluminum.

In the manufacture of paper pulp by the sulphite process, one of the obstacles has been the difficulty of securing a metal that will not be affected by sulphurous acid gas and which at the same time is free from mechanical drawbacks. Sulphurous acid gas is an essential feature of the sulphite pulp process and the pipes required for handling it in a large mill are quite extensive. Prior to the introduction of aluminum, bronze pipe was commonly used, but it deteriorates rapidly under the action of SO_2 gas and its replacement has been a constant source of expense. Aluminum, on the other hand, is but slowly affected by the gas and an installation of it can be regarded as practically permanent. The accompanying drawing "A" shows an aluminum cooler for reducing the temperature of SO_2 gas after leaving the digester where the pulp is treated or "cooked." It is in service at the Champion International Paper Company's plant at Lawrence, Mass.



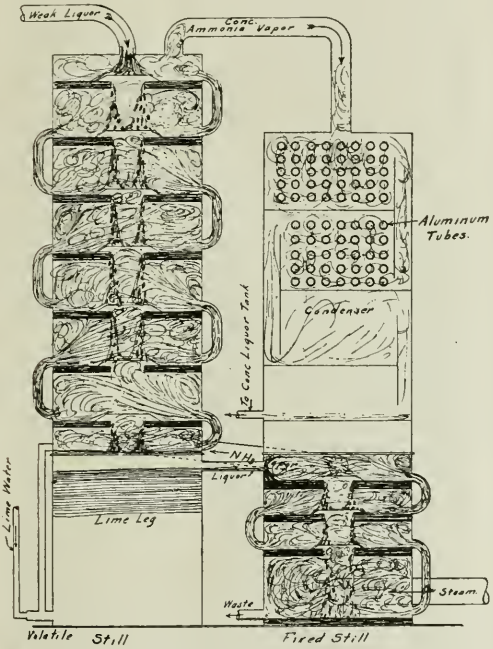
A—Aluminum Relief Line System for Sulphate Pulp Process.

The production of ammonia as a by-product of coke involves the use of condensing apparatus to cool the ammonia gas, either at the top of the concentrator or in a separate compartment near by. Pure ammonia is destructive to copper and copper alloys, and the usual impurities in crude ammonia, viz.: hydrogen sulphide, sulphurous and sulphuric acid gas, attack iron. Aluminum has the double quality of resisting ammonia and its common impurities. Some of the large by-product coke oven companies use it, but its use has not spread to the smaller companies. Illustration "B" shows location of aluminum tubes relative to the main portion of the concentrator.

One of the principal uses of aluminum tubing, as well as other forms of aluminum, is in the manufacture

*Metal Industry, March, 1910.

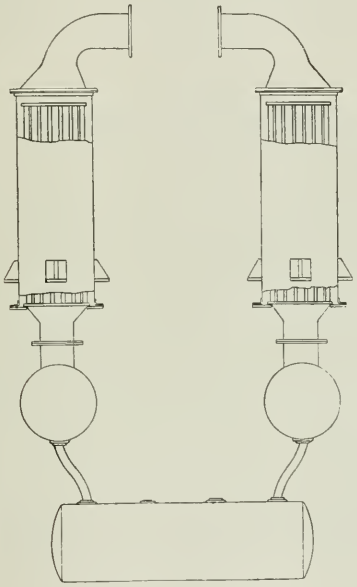
of stearic acid and in the production of soap, candles and other products where stearic acid is the principal constituent. Stearic acid for use in soaps should be free from color, a result which is impossible to secure if the apparatus and pipes by which it is made and carried from place to place are made of copper. The verdigris which gathers on copper surfaces during the periods when the apparatus is not in use wears off and strains the product in the first few days of operation. In stearic acid for candles any mineral matter is likely to gather on the wick of the candle and cause it to burn irregularly. As aluminum has been found to be absolutely free from corrosion by stearic and similar acids, it is used in practically all candle factories and



B—Typical Ammonia Concentrator Showing Location of Aluminum Tubes.

many soap concerns having careful regard to the quality of product. Illustration "C" shows condensing apparatus for hot stearic acid, made of aluminum and connected by aluminum pipes. The principle of protecting one metal by another which is electro-positive to it, has a striking example in aluminum-lined condenser tubes. The principle is the same as that of coating black iron plate with zinc, i. e., by making what is known as galvanized iron. Zinc is electro-positive to iron; consequently when a sheet of steel is coated with zinc and afterwards exposed to the weather, the moisture existing in the air causes galvanic action between the steel plate and its zinc covering. The zinc rather than the iron is affected and a thin coating of zinc oxide, very resistant to corrosion, is formed and prevents the iron from being attacked. Similarly, copper coated with aluminum, as in the case of an aluminum-lined condenser tube, is not affected by the action of whatever cooling agents may be passing through the tube, until such time as the aluminum lining, which is generally also quite resistant to corrosive action, has been eaten away. Condenser tubes made on this principle have been known to last twice as long as brass and copper under similar circumstances.

Aluminum tubing, solely on the basis and strength, is not preferable to copper. In common with most metals it is improved by cold working. The tensile strength of hard drawn aluminum tube 1 inch outside diameter and with walls .065 inches thick is approximately 23,000 pounds per square inch. A test of the strength by subjecting the tube to water pressure



C—Condenser System with Tanks for Stearic Acid.

shows a maximum fiber stress of about 22,000 pounds per square inch. The difference is due to the fact that a bursting test strains the tube across the grain, whereas the usual test by pulling is with the grain. Similar copper tubes under the same water pressure test will resist approximately 36,800 pounds per square inch of surface exposed, which is equivalent to a maximum fiber stress of 33,000 pounds per square inch. For practical purposes in the design of apparatus requiring tubes, aluminum can be reckoned at about the same strength as copper, except in cases where heavy pressures are to be sustained. In such instances the thickness of aluminum pipe should be increased and carefully proportioned to the strain to be resisted. As the main use of seamless tubing of brass, copper or aluminum is for the purpose of cooling or evaporating, the ability of the metal to transfer heat is an important

question, although its importance is often over-estimated.

The resistance to transmission of heat is mainly by the scale of incrustating material that gathers on the inside or the outside, whichever may be opposite the cooling agent. Perfectly clean tubes will transmit about the same amount of heat, regardless of the metal of which they are made, although by very careful measurements it has been found that the metal makes a certain difference, the amount of variation being measured with considerable accuracy by the difference in electrical conductivity. None of the commercial metals are superior to copper in this respect. The heat-carrying power of copper is reduced by the admixture of an alloying ingredient in the same way that its power to transmit electricity is reduced. Steel and lead have a comparatively high resistance to the transmission of heat. The efficiency of aluminum is less than that of copper and more than that of the other metals mentioned.

LIQUID AIR AS AN EXPLOSIVE.

Liquid air was first used as an explosive only in combination with other substances. It is now used alone, its explosive power depending upon its property of turning suddenly into vapor at an elevated temperature. If the vessel in which the liquid air is contained is sufficiently tight, very high expansive powers are attained. For this reason it is stored in vessels having a small opening. This property of the liquid air makes it necessary to place the cartridge in place in the rock before it is loaded. In English mines the cartridges are made of thick phosphor-bronze, the loading being calculated so that the pressure reaches 5.6 kg. per sq. cm. The explosion takes place in six or eight minutes after loading and about 30 tons of coal are broken by one shot. The coal falls in blocks about 60 cm. in circumference. A heavier loading of the cartridge causes the coal to be broken into powder.

The present value of tungsten ore in the United States is $6.50 to $7 per unit per ton of 2,000 lbs. for ore containing 60 per cent of tungsten trioxide. This price is paid for ferberite, wolframite and hueberite ores.

For special lots of very high-grade ore more is paid, depending upon the analysis, etc. Scheelite ores command from 50c to $1.50 per unit less than the above prices. The market for tungsten ores fluctuates very much and it is difficult to state prices that hold good for any great length of time.

Hydrogen is evolved in the zinc-boxes when the solutions are precipitating. As a rule, the character of the precipitation can be determined after a little practice by observing the rate at which the gas is evolved. A rapid flow of gas usually indicates that the boxes are working satisfactorily.

AVERAGE EFFICIENCIES OF VARIOUS CLASSES OF MACHINERY.

The following values, as gathered from various sources by Mr. Alfred T. Best and included in an article recently published in The Mechanical Engineer, may be taken as fair averages; they must, however, be used with discrimination, as there is often a wide variation between individual examples:

Thermal Efficiency—Steam boilers, 50 to 85 per cent.

Indicated Thermal Efficiency—Steam engines (greater for condensing engines than for non-condensing engines), 6 to 11 per cent; gas engines, 20 to 37 per cent.

Mechanical Efficiency—Steam engines (greater for simple non-condensing than for compound condensing engines), 75 to 94 per cent; gas engines, 65 to 88 per cent; undershot water wheels, average, 35 per cent; Poncelet's water wheels, 60 per cent; low-breast water wheels, 55 per cent; high-breast water wheels, 69 per cent; overshot water wheels, 68 per cent; turbines, 70 to 80 per cent; reciprocating pumps, average, 90 per cent; double-acting combined steam engines and pumps, 80 to 86 per cent; centrifugal pumps (varying with conditions), 25 to 75 per cent; hydraulic rams (varying with head), 10 to 75 per cent; hydraulic presses or lifts, rapid 50 per cent, slow 90 per cent; fans, average, 50 per cent; belt conveyors, 50 per cent; compressed air motors, 50 per cent.

Losses—Compressed air mains (say) 10 per cent per mile; shafting alone (say) 2 per cent per 100 ft.; shafting, belting and gearing, according to extent and to number of changes, 5 to 50 per cent or more.

Electrical Efficiency—Dynamos or generators, 90 to 96 per cent; electric motors, 75 to 90 per cent; transformers, 90 to 95 per cent.

Self-hardening steel was the result of a discovery by Robert Mushet. He found that by the addition of certain quantities of tungsten, chromium and manganese to ordinary steel, the steel became nearly as hard on cooling in the air from a forging heat as when tempered in water. Since then various mixtures have been discovered, each of which possesses certain peculiar properties, which make it of great value for certain classes of work. The original Mushet steel has a cutting speed of 26 ft. per minute, but many modern high-grade steels have a cutting speed of 100 ft. per minute.

Copper can be welded by employing a welding compound consisting of one part sodium phosphate and two parts boric acid. The copper should be brought to a dull red heat and the compound placed between the faces to be welded. The copper should then be well hammered. Considerable care must be taken to prevent any carbonaceous matter remaining between the faces.

A RAPID METHOD FOR THE IDENTIFICATION OF GAS OILS.*

By F. E. PARK AND L. E. WORTHING.

The following data have been gathered in an attempt to develop a means of distinguishing between gas oils derived from different fields. While it is manifestly impossible for an ordinary laboratory to attempt to separate and determine the constitution of the numerous hydrocrabons of gas oils, a simple method of determining the type of oil at hand would often be useful.

From several standpoints a method of identification of gas oils seems desirable. A great deal of the data on water gas oil results is conflicting. This may possibly be due to a difference in composition of the oil used, a difference which could not be determined by ordinary tests. Some slight attempts have been made to determine the gas making properties of various gas oils by small scale experiments, but the most reliable information on the values of gas oils for gas making purposes is likely to be obtained from their actual use in water gas practice. Data collected from actual practice require positive and simple methods of identification of the oil in use or a method adapted to the average gas works laboratory. Such a method would aid in the interpretation of results collected from various sources, tend to explain discrepancies, and render results reported in gallons per 1,000 more intelligible.

Moreover, the most apparent application of a method of this kind is as an additional check on oil shipments. When water gas results fall off unexpectedly, it becomes important to discover if there has been a change in the quality of the gas oils. Specific gravity tests and fractionations do not throw a great deal of light on the subject, but further tests are usually dispensed with, as they are expensive, tedious and liable to be unsatisfactory. Luckily, to prove a change in the oil it is not necessary to determine its constitution; any simple test serving to identify the oil is sufficient. It is proposed to use the bromine absorption number, which may be readily determined, for this purpose. Before proceeding to describe the process of bromination, it may be well to review briefly the chemical composition of petroleum.

Nature of Petroleum.—In defining petroleum, Mabery states: "Now, after years of hard labor, I have reached the conclusion that petroleum from whatever source is one and the same substance, capable of simple definition—a mixture in varying proportions of a few series of hydrocarbons, the product from any one field differing from any other field only in the proportion of these series and number of the series."

Eight series of hydrocarbons, to each of which a generalized formula may be assigned, are found in petroleum, ranging from the paraffines to the naphthalines:

1. C_nH_{2n+2} ..... Paraffines.
2. C_nH_{2n} ..... Olefines and polymethylenes.
3. C_nH_{2n-2} ..... Acetylenes.
4. C_nH_{2n-4} ..... Asphaltic hydrocarbons.
5. C_nH_{2n-6} ..... Benzenes.
6. C_nH_{2n-8} ..... Phenylethenes.
7. C_nH_{2n-10} ..... Phenylethines.
8. C_nH_{2n-12} ..... Naphthalines.

These expressions, of which only the first five are important, are of use simply as a general classification of oils. Each one represents a group or series—homologous, isomeric or polymeric. In addition to the hydrocarbons, there are present, of course, a variety of related compounds containing oxygen, sulphur and nitrogen. Such compounds, however, occur in small volumes as compared with the hydrocarbons.

The first formula, C_nH_{2n+2}, represents the paraffine hydrocarbons, of which the first member is methane, CH_4, and which ranges at least as high as $C_{35}H_{72}$. The paraffines are the most important of the open chain or aliphatic series. They are the principal constituents of Pennsylvania petroleum and have been found in all petroleum except California.[1] Each member differs from the preceding one by CH_2. As the number of carbon atoms increases, the number of isomers (compounds having the same percentage composition but differing in the atomic arrangement) increases rapidly.

The liquid members follows:

Name.	Chemical Formula.	Melting Point.	Boiling Point.
Pentane	C_5H_{12}	37° C.
Hexane	C_6H_{14}	69
Heptane	C_7H_{16}	98
Octane	C_8H_{18}	125
Nonane	C_9H_{20}	— 51° C.	150
Decane	$C_{10}H_{22}$	— 31	173
Endecane	$C_{11}H_{24}$	— 26	195
Dodecane	$C_{12}H_{26}$	— 12	214
Tridecane	$C_{13}H_{28}$	...
Tetradecane	$C_{14}H_{30}$	+ 4	252
Pentadecane ...	$C_{15}H_{32}$	...
Hexadecane	$C_{16}H_{34}$	18	...

To this must be added the isomeric forms, which

*Read at the 4th Annual Meeting of the American Gas Institute.

[1] Mabery and Hudson, "American Chemical Journal," April, 1901, p. 255.

differ slightly in boiling points and physical properties from the normal compounds.

C_nH_n represents the composition of two important types of oils. First, the olefines or unsaturated open chain compounds; second, the aromatic closed ring compounds, the benzine hexahydrides, naphthenes, or polymethylenes—as they are now usually called. The olefines are not as important a constituent of petroleum as formerly supposed. In fact, they have only been positively identified in Canadian oil.[2]

The naphthalines or polymethylenes are notably present in Russian petroleum, in which they were first studied. Attention was drawn to them because of the similarity of their properties with the paraffines. They have since been identified as the predominate constituents of California and Texas petroleum, and are present in Ohio Trenton limestone oil. Members of the series from C_7H_{14} to $C_{15}H_{30}$ were isolated from California crude.

The series C_nH_{2n-2} is called the acetylene series after its first member. The lower members, however, are never found in petroleum. Texas oils contain hydrocarbons of series C_nH_{2n-2} from $C_{11}H_{20}$ to $C_{19}H_{36}$. These hydrocarbons are characteristic of oil from Texas, Louisiana and Ohio. Compounds of this formula are certainly not all true acetylenes. The isomers can be explained by the assumption of two methylene rings connected as in the manner of diphenyl, with a sufficient number of side chains or connected carbon atoms between rings to account for the formula.

In oil from Trenton limestone, Maybery and O. H. Palm[1] found hydrocarbons having the composition $C_{19}H_{36}$, $C_{21}H_{40}$, $C_{22}H_{42}$ and $C_{24}H_{46}$. With those compounds were members of the C_nH_{2n} series as high as $C_{17}H_{34}$. Texas oils contain the next series C_nH_{2n-4} from $C_{20}H_{36}$ to $C_{23}H_{46}$. This series also predominates in the heavy asphaltum oils from Louisiana.

There are probably oils of series containing much less carbon in the higher fractions of Louisiana and Texas oils, but decomposition on fractionation prevents separation necessary in order to study the pure compounds. The most promising method of getting at the constitution of these heavy hydrocarbons is by fractional filtration through Fuller's earth.

The series C_nH_{2n-6} represents the benzenes or aromatic hydrocarbons. Traces of benzines have been found in nearly all oils, even in Pennsylvania oils. The lighter fractions of California oil, however, contain the largest percent of hydrocarbons of this series, which includes, of course, the toluols and xyols.

1. Benzine .. C_6H_6.
2. Tolnol .... C_7H_8.
3. Xylol .... C_8H_{10}.
4. Cumene.. C_9H_{12}.
5. Cymene.. $C_{10}H_{14}$.

Maybery and Hudson[2] in fractionating a California oil found 35 per cent benzine in a fraction boiling near 80° C., in the 109 to 110° C. fraction 70 per cent toluol, 135 to 140° C. fraction 75 per cent xylol, and at 220 to 222° C. the distillate was solid with naphthaline. If there are any paraffines in California oil they occur in distillates below 70° C.[3].

Members of C_nH_{2n} and C_nH_{2n-10} series have also been identified in small amounts in California petroleum. The oil from the mid-continental fields has a wide variation in composition and contains many different series. Small quantities of oxidized compounds are found in petroleum as acids and phenols. Phenols occur principally in California oils. Nitrogen is found in all oils, and in the case of California oil, compounds of the formula $C_{12}H_{17}N$ to $C_{17}H_{21}N$ constitute from 10 per cent to 20 per cent of the crude petroleum. The nature of the sulphur compounds in petroleum is not well understood. It appears in many forms from occluded H_2S to so-called thiophanes. In Lima oil sulphur appears to be in the form of sulphides. Ten compounds, from C_2H_6S to $C_{12}H_{26}S$, have been isolated.[4] Canadian petroleum in the higher fractions contains compounds of the formula $C_nH_{2n}S$[5]. Texas oil, besides organic sulphur, contains large amounts of free hydrogen sulphide.

Summarizing the characteristics of the principal American oils: Texas oil is remarkable for its asphaltic inert properties, Pennsylvania paraffine oil is even more chemically inert, California oil contains benzines, and Canadian oil contains open-chain unsaturated hydrocarbons. The other types have less striking peculiarities. As gas oils usually are fractions of about 33° B., they contain not only a portion of the original oil, but are liable to contain products of decomposition caused by cracking. These decomposition products may cause the oil to exhibit properties—as it does indeed contain compounds—completely different from the original.

Process of Bromination.—The notion of treating hydrocarbon oils with bromine has been derived from the custom of identifying vegetable or animal oils by their so-called bromine or iodine numbers. The idea of determining the amount of bromine an oil will take up is not a recent one, but dates back to 1857, to Cailletet, a Frenchman, who describes a method of treating oil with an alcoholic solution of bromine and titrating the excess bromine with a turpentine solution until the color is discharged.

In 1881, A. H. Allen proposed a method for brominating oil in which the bromine was liberated in contact with the oil by the decomposition of a water solution of sodium hypobromite with hydrochloric acid. Two years later Mills and Snodgrass proposed the use of carbon bisulphide as a solvent. These various schemes were all intended, principally at least, for the identification of vegetable or animal oils, which gave charac-

[2] Mabery, "American Chemical Journal," Vol. 33, p. 251.
[1] American Chemical Journal, Vol. 33, p. 251.
[3] "Chem. Ind.," 1900, p. 502.
[3a] "American Chemical Journal," Vol. 13, p. 233.
[4] "American Chemical Journal," Vol. 13, p. 233.
[5] Proceedings Am. Acad., Vol. 41, p. 89.

teristic bromine absorptions, and for the detection of their adulteration.

The most satisfactory method involves the use of carbon tetrachloride as a solvent. This scheme was first used by McIlhenny[1] and is recommended principally because of the increased stability of the carbon tetrachloride bromine solution, and of a sharper end point in titrating. One of the reasons for the increased stability of the carbon tetrachloride over the carbon bisulphide can be inferred from a consideration of their boiling points.

Carbon bisulphide boils at 43° C.; bromine, at 63° C.; carbon tetrachloride at 77° C.

Another is the fact that carbon bisulphide forms various sulphur bromides in solution and liberates free hydrobromic acid.

The method we have used is an adaptation of McIlhenny's. Twenty-five c. c. of a tenth normal solution of bromine in carbon tetrachloride, previously standardized against sodium thiosulphate, is agitated with ¼ to ½ gram of the oil to be tested in a stoppered Erlenmeyer flask. Before mixing, the sample of oil should be dissolved in 25 to 30 c. c. of carbon tetrachloride. The mixture is then allowed to stand in the dark for 30 minutes. The carbon tetrachloride solution and the oil to be tested should be previously dried by use of a few sticks of fused calcium chloride.

At the end of 30 minutes about 100 c. c. of distilled water is added to the flask, with 2 grams of potassium iodide, and the unabsorbed bromine titrated against a tenth normal sodium thiosulphate water solution. Starch solution is used as an indicator. The end point is reached when the bromine color of the oily layer has disappeared, and the iodine blue of the starch and water solution is just discharged. The oily carbon tetrachloride solution should appear red before titrating or insufficient bromine solution has been used.

The hydrobromic acid formed during the bromination is titrated against sodium thiosulphate by adding half a gram of sodium iodate to the flask, after the titration is finished, and titrating to the second disappearance of the blue color. Or, the hydrobromic acid may be titrated against N/100 caustic after separating from the oily layer. Better results can be obtained from the iodate method by first separating the oily layer from the water solution.

Both the absence of sunlight, and the careful drying of both oil and tetrachloride are most necessary, as light accelerates the bromination of the saturated compounds, giving rise to an undue proportion of substituted bromine; and the presence of the smallest amount of moisture is even more effective in accomplishing the same result. The addition of the bromine solution and subsequent titration with sodium thiosulphate need not, however, be made under artificial light, as by carefully duplicating the conditions of experiment very concordant results may be obtained. The total bromination number is the number of grams of bromine absorbed per 100 grams of oil. The bromine substitution number is the amount of bromine found as hydrobromic acid after the bromination is completed, calculated to the same basis. The bromine addition number is calculated by subtracting twice the bromine substitution number from the total bromination. This calculation is based on the following equations:

$$\underset{\text{(Ethylene)}}{2C_2H_4} + Br_2 = \underset{\text{(Ethylene bromide)}}{2C_2H_4Br}. \quad \text{or,} \quad \underset{\text{Ethylene)}}{C_2H_4} + Br_2 = \underset{\text{(Ethylene di-bromide)}}{C_2H_4Br_2}$$

Example of substitution:

$$\underset{\text{(Toluol)}}{C_6H_5CH_3} + Br_2 = \underset{\text{(Hydrobromic acid)}}{C_6H_5CH_2Br} + HBr.$$

It is evident that for every substituted bromine compound formed an equal amount of hydrobromic acid is formed. Hence, it is necessary to deduct both the bromine of substitution and the hydrobromic acid bromine from the total absorption to find the amount going to form addition products. Both the olefines and the acetylenes form addition products, so that in a general way it may be assumed that large addition numbers indicate acetylenes, olefines, or ring compounds with unsaturated side chains. Large substitution numbers—benzines and small total bromination—paraffines or naphthenes. If paraffines were attacked by slight exposure to daylight, substitution products would be formed.

While it would not be fair to assume that the members of the different series are present in direct proportion to the substitution, addition, or absence of bromination in the case of a single oil, between the various oils the results of bromination would indicate which oil contained more of a particular series.

The above described process was carried out on samples of oils differing largely in character and from widely separated fields. Through the courtesy of the St. Louis, San Antonio, Los Angeles and Denver Gas Companies, and the Standard Oil Company, we received samples of gas oils of the principal types found in the United States. We also tested samples of Canadian crude. Fractionations, sulphur content, heat values and bromine absorption are given in Table No. 1 and No. 2.

Pennsylvania oil, Florence, Col., Boulder, Col., and Texas oil appear to have a predominance of paraffines or naphthalines. Detroit City Gas Company's oil and Laclede (St. Louis) oil seem to be largely olefines or unsaturated ring compounds, while Los Angeles oil is remarkable for the presence of benzines, and Canada oil for the absence of them.

The proportionate large amount of additional bromination in the case of Canadian crude is further evidence of the presence of small amounts of olefines. The apparent presence of olefines or other unsaturated compounds in the Detroit City Gas Company's oil and in the Laclede is probably due to the cracking of the original oil. Toluol shows exactly the theoretical substitution, xylol shows a preponderance of substitution and some additional products probably due to impur-

[1] "Jour. of Am. Chem. Soc.," Vol. 16, p. 275; Vol. 2, p. 1684.

nies. Both these products, of course, belong to the benzine series.

The lack of action in the case of benzine is to be expected in the absence of carrier. It is readily brominated in the presence of certain foreign bodies which promote the action. The failure of benzine to react with bromine in a pure state indicates what an important effect a mixture of oils and the products of

Table No. 1.—Fractional Distillation.

Name.	Specific Gravity.	Point of Distillation.	Up to 302° F.	302 to 573° F.	572 to 662° F.	662° up.	Distillation Loss.
Laclede, St. Louis.	31.7 B.	106° F.	4.3 p.c.	30.7 p.c.	39.3 p.c.	20.7 p.c.	5.0 p.c.
	Spec.	grav.:	59.2 B.	38.7	30.7	26.2	Carbon.
Denver G. & E.	32.4	164	3.3	37.3	44.3	14.3	0.8
Co.	Spec.	grav.:	60.4	35.7	30.3	26.3	Carbon.
Florence, Col.	34.0	130	3.7	34.3	45.7	16.0	0.3
	Spec.	grav.:	44.8	36.3	34.0	30.0	Carbon.
Sugar Creek, Mo.	32.5	173	4.0	37.7	21.7	33.3	4.3
	Spec.	grav.:	53.8	38.0	31.3	27.0	Paraffine.
Florence, Col.	30.9	104	1.0	7.7	37.7	53.0	0.6
No. 2	Spec.	grav.:	...	40.9	33.3	29.6	Carbon.
Boulder, Col.	32.0	168	0.7	1.7	27.7	66.0	3.9
	Spec.	grav.:	...	...	33.7	32.4	Paraffine.
Canada, Crude	41.9	174	19.3	43.3	31.7	1.0	4.7
	Spec.	grav.:	57.2	46.1	37.3	...	Pitch.

Table No. 2.

Name.	Spec. Grav.	Total Bromination.	Bromination Substitution.	Bromination Addition.	Sulphur.	B.T.U.
D. C. G. Co. Utl. 11, 831	34.3	26.67	6.42	13.83	0.26	18,867
San Antonio, Tex.	22.1	10.38	3.57	3.24	2.09	18,750
Los Angeles, Cal.	20.1	22.22	9.81	2.60	0.80	18,538
Pennsylvania	34.4	11.20	2.09	5.22	0.26	18,843
Laclede, St. Louis	31.7	24.98	5.45	14.04	0.56	19,526
Denver G. and E. C.	32.3	10.70	2.58	5.54	0.52	18,851
Florence, Col.	34.0	5.48	1.48	2.52	0.31	20,131
Sugar Creek, Mo.	32.4	16.41	4.46	7.49	0.25	19,311
Florence, Col., No. 2.	30.9	14.15	3.37	7.41	0.35	18,904
Boulder, Col.	32.0	7.98	2.40	3.18	0.28	.....
Canada crude	41.8	4.87	0.46	3.95	0.50	.....
Pentane	...	0	0	0	0	.....
Toluol	...	2.80	1.40	0	0	.....
Benzol	...	0	0	0	0	.....
Xylol	...	6.34	2.43	1.48	0	.....

Name.	Specific Gravity.	Point of Distillation.	Up to 310° F.	310 to 475.	475 to 570.	570 to 690.	690 up.	Distillation Loss.
Utl. 11,831 D. C. Gas Co.	34.4	211	7.3	29.3	21.3	32.7	8.3	1.1
Special grav.	...		53.7	40.5	33.5	28.5	26.5	Carbon.
San Antonio, Tex.	22.1	172	3.3	13.0	22.7	53.0	4.2	2.1
			(1.7 water.)					
Special grav.		...	51.3	35.1	27.8	23.0	Asphalt.	Carbon.
								10 per ct.
Los Angeles, Cal.	20.1	218	5.7	15.3	12.0	33.7	21.3	asphalt.
								2 p.ct. loss.
Special grav.		...	54.3	39.6	29.3	24.1	22.1	Carbon.

bromination may have on the amount of bromine absorbed. To test the effect of mixing oils on bromine absorption, the Detroit and San Antonio oils were mixed in exactly equal proportions by weight with the following results:

By test:	
Average total bromine absorbed	20.60
Average substitution	5.36
Average addition	9.88
Same by calculation:	
Average total bromine absorbed	18.52
Average substitution	5.00
Average addition	8.53

purities in oil have the effect of accelerating slightly the bromination of hydrocarbons aside from their own action in absorbing bromine. Hydrogen sulphide is the impurity which probably causes the greatest error in interpretating the results of bromination, as it forms hydrobromic acid and free sulphur. If all the 2.09 per cent of sulphur in San Antonio oil were hydrogen sulphide, the error would be 5.2 grams of bromine per 100 grams of oil, or sufficient to account for half the total bromination. However, in oils giving large bromine absorptions the amount of hydrogen sulphide present is nil, or negligible and the possible error due to its presence is very slight. To test the

TABLE No. 3.

Kind of Oil.	Car. No.	Specific Gravity.	Total Bromination.	Addition.	Substitution.
Sta. A Utl.	11,831	34.4° B.	26.67	13.83	6.42
Sta. A Utl.	8,553	36.1	28.18	14.06	7.06
Sta. A Utl.	7,867	36.0	29.45	14.39	7.53
Sta. A Works, pump	.....	36.1	31.35	16.03	7.66
Sta. B Utl.	8,513	33.6	32.07	15.33	8.31
Sta. B Utl.	7,545	33.6	33.07	14.54	9.23
Grand Rapids Utl.	9,405	33.0	27.18	0.54	8.82
Laclede, St. Louis	.....	31.7	24.98	14.04	5.45

Effect of mixing benzine and Florence oil:	
Average total bromine absorbed	4.91
Average substitution	2.12
Average addition	0.68
By Calculation:	
Average bromine absorbed	2.74
Average substitution	0.74
Average addition	0.63

value of the method in identifying a single type of oil, the following samples were brominated:

Grand Rapids and St. Louis gas oils are included in the above table only because they are all approximately of the same type. Detroit gas oil has the following average bromination numbers:

Total Bromination.	Addition.	Substitution.
30.13	14.73	7.70

TABLE No. 4.

Oil.	Specific Gravity.	Total Bromination.	Addition.	Substitution.	Authority.
Shale	35.8° B.	48.2	....	...	Allen[1]
American pet.	36.6	32.3	....	...	"
Russian pet.	32.0	1.9	1.70	.10	"
Cal. pet. Puente Field.	....	18.8	....	...	Mabery[2]
Puente Field.	....	18.3	....	...	"
Shale	33.5	22.24	....	...	Mills and Snodgrass[3]
Shale	31.9	20.59	....	...	"
Shale	28.0	12.59	....	...	"
Shale	26.0	11.72	....	...	"
Mineral	45.0	27.57	....	...	"
Illuminating	45.5	30.31	....	...	"

It is apparent that the effect of increasing the number of constitutents increases the amount of bromination. The total bromination of a mixture may then be assumed to be above figures calculated from bromination numbers of pure constituents. Evidently, im-

It varies from the average figure by + 9.8 per cent to — 10.7 per cent. Such variation would be expected

[1] "Commercial Organic Analysis," Vol. 2, p. 95.
[2] "American Chemical Journal," April, 1901, p. 255.
[3] "Journel Society Chemical Industry," Nov. 29, 1883, p. 336, 435.

in view of the range in specific gravity from 33.6° B. to 36.1° B. The Denver Gas Co.'s oil shows a striking similarity to the Pennsylvania gas oil, and, in turn, to the San Antonio gas oil, though the first two are undoubtedly largely paraffines and the last a polymethylene or naphthaline. An idea of the bromine values of oils which are published can be obtained from Table No. 4.

The report of Mills and Snodgrass on shale oil in the above table shows that the absorption of bromine with shale oil varies inversely as the density of the oil.

Summary.—By treating gas oils with bromine dissolved in carbon tetrachloride, under specified conditions, a characteristic bromine absorption number can be obtained having an allowable variation of ‡ 10 per cent, which may be used to identify the oil and serve as an additional check on the composition of gas oils, besides the specific gravity and fractionation tests. As an aid in distinguishing between saturated and unsaturated hydrocarbons, the amount of hydrobromic acid formed during the bromination is determined. The total amount of bromine absorption and the per cent of hydrobromic acid formed are considered together in deciding as to the type of oil. For purposes of water gas manufacture the method is exceedingly reliable and sufficiently accurate, and, in the case of a single sample, the addition and substitution numbers may, by carefully duplicating the conditions of experiment, be checked to within 1/10 gram of bromine in every case. The 50 c.c. burettes are the only apparatus required. About two hours are necessary for a duplicate determination.

Comparatively little wrought iron is used in America, mild steel being almost always employed instead. Users have been loud in their complaints about the inability of this steel to withstand the attacks of the weather. It is noteworthy, therefore, that recently a non-rusting iron has been introduced by the American Rolling Mill Co. at Middletown, Ohio. The carbon, manganese, and silicon contents are extremely low, being 0.05 per cent, 0.01 per cent and 0.02 per cent, respectively. The ultimate tensile strength is from 47,000 to 49,000 lbs., and its ductility is high. The resistance to corrosion is remarkable. Experiments with moisture and acids show that these have little effect. The steel is made in the basic open-hearth furnace and the oxidizing action is carried farther than usual. No ferro-manganese is used, but ferro-silico is added to remove oxides. Aluminum is added in the ladle in order to remove occluded gases.

Nickel-steel for automobile construction contains about 0.2 to 0.25 per cent carbon, 3.5 nickel, 0.6 to 0.9 manganese, with sulphur and phosphorus together not exceeding 0.04. A slightly lower carbon is sometimes used for case-hardening. This steel is especially suitable for heat-treatment and for case-hardening.

RAPID ANALYSIS OF BABBITT METAL.[1]

By PERCY H. WALKER AND H. A. WHITMAN.

Chemists Contracts Laboratory, U. S. Dept. of Agriculture.

1. COPPER.

Weigh 1 gram of the alloy into 250 c. c. beaker, add 20 c. c. of hydrochloric acid and 5 c. c. of water, heat, and complete the solution by adding nitric acid in small amounts; with most alloys solution can be effected in a very few minutes and without adding more than 1 or 2 c. c. of nitric acid. Evaporate off the acid on a steam bath. It is not necessary to carry to complete dryness, but practically all the acid should be driven off and the residue should be pasty. Add 25 c. c. of a solution made of 200 grams of tartaric acid and 260 grams of potassium hydroxid, the whole being made up to 500 c. c. with water. Heat on the steam bath until solution is completed, add 25 c. c. of water, boil, add 25 c. c. of a 0.2 per cent invert sugar solution, boil for two minutes, filter through asbestos, wash the precipitate of cuprous oxid with water, dissolve in nitric acid, catching the copper solution in a 200 c. c. flask, and determine copper by any good volumetric method. Equally good results can be obtained by following Low's iodid method[2], or Jamieson, Levy and Well's thiocyanate and iodate method.[3] The results are uniformly a little low. This error is not due to the volumetric methods employed, both of which give exceedingly accurate results, but to the fact that nearly 6 per cent of the copper present is not precipitated as cuprous ovid. This loss is uniform, for if we add 6 per cent of the copper determined, the result will be the per cent of copper in the alloy.

The statement is frequently made that if a babbitt metal is decomposed by nitric acid, evaporated to dryness, taken up with nitric acid and filtered, copper can be determined in the filtrate with an error of not more than one or two-tenths of 1 per cent. This is not the case, as the error with an alloy containing 5 per cent of copper will frequently be from 0.5 to 0.7 per cent, while by the method just described without correction the error will be less than 0.3 per cent, and by applying the correction this error is removed entirely.

2. LEAD.

Dissolve 0.5 to 1 gram of alloy in a 250 c. c. beaker as in the determination of copper; when solution is complete evaporate to dryness on the steam bath, add 5 c. c. of strong hydrochloric acid (with as much as 10 per cent of antimony use 10 c. c. of hydrochloric acid), warm for a few minutes, remove from steam table, add, with stirring, 150 c. c. of 95 per cent alco-

[1] J. Ind. and Eng. Chem. I, 519.
[2] J. Am. Chem. Soc., 24, 1082.
[3] Ibid., 30, 760.

hol, let stand at room temperature for two hours, filter on a Gooch crucible, and wash with 95 per cent alcohol, using about 100 c. c. suck as dry as possible, dry crucible in an air bath (one hour at 105° C. is sufficient, though the lead chlorid can be heated at 150° C. with perfect safety). Weigh as lead chlorid, add 0.0085 gram to the weight of the precipitate, and multiply by 0.74473; the product gives the weight of lead.

3. ANTIMONY.

Antimony is determined by W. H. Low's method[1] slightly modified as follows: To 1 gram of alloy in a 450 c. c. Erlenmeyer flask add 10 to 15 c. c. of strong sulphuric acid, and heat on a hot plate until the alloy is thoroughly decomposed. This is generally accomplished in about thirty minutes from the time fumes of sulphur trioxid begin to be given off. Cool, add 200 c. c. of water and 20 c. c. of strong hydrochloric acid, boil to make sure that all sulphur dioxid is driven off, cool and titrate rapidly with potassium permanganate which has been standardized against metallic antimony. The true end-point is found when a pink color shows after agitating the liquid, though this pink will very soon disappear. The only change made in the Low method of procedure is to add somewhat less hydrochloric acid. The results are sufficiently accurate for commercial purposes, but the tendency is to get results 0.3 to 0.4 per cent high.

4. TIN.

Tin is also worked by W. H. Low's method,[1] except that it seems to be more satisfactory to use a separate portion of the alloy and reduce with steel turnings instead of with metallic antimony. Treat from 0.2 to 1 gram of alloy (do not use an amount of alloy containing more than 0.2 gram of tin) in a 450 c. c. Erlenmeyer flask with 10 to 15 c. c. of strong sulphuric acid, heat on the hot plate until the alloy is thoroughly decomposed, cool, add 200 c. c. of water, 30 c. c. of strong hydrochloric acid, and about 1 gram of steel turnings, heat, and when reduction appears complete, but before the last particles of steel have dissolved, place a two-hole rubber stopper in the neck of the Erlenmeyer flask—one hole of the stopper should carry a tube reaching below the surface of the liquid, the other hole should carry a short arm of a bent tube, the long arm of which reaches nearly to the bottom of a 100 c. c. Erlenmeyer flask containing a solution of sodium bicarbonate. This small Erlenmeyer is held on the bent tube by a cork which has a notch cut in it to act as a vent. Through the tube reaching below the surface of the liquid in the large Erlenmeyer pass a current of carbon dioxid, heat to boiling until all steel is dissolved, continue passing carbon dioxid, and cool as quickly as possible; loosen the stopper but let the current of carbon dioxid continue; add cautiously some starch solution and titrate with tenth-normal iodin. It is necessary to absolutely exclude air and to standardize the iodin solution with pure tin.

[1] J. Am. Chem. Soc., 29, 66.

BOOK REVIEWS.

HOUSEHOLD CHEMISTRY. By H. T. Vulte and G. A. Goodell. Second edition, 12 mo. Cloth. Illustrated. V-190 pages. Chemical Publishing Co., Easton, Pa.

This little book is designed for the use of students of domestic science and presupposes a knowledge of the elements of chemistry on the part of the latter. It is divided into two parts, the first of which is devoted to the chemistry of fuels, water, air, metals and alloys, acids and bases, glass, pottery, paints and varnishes. The second part is devoted to foods. A concluding chapter of this also deals with stains, something which will no doubt interest those of the students of domestic science who belong to the fairer sex. A large number of simple analytical tests are described, but there seems to be lacking any attempt, particularly in Part I, to instruct as to the scientific use of the substances described. It would seem to the reviewer, for example, much more important to describe the principles of the economic combustion of fuels rather than tests merely to show the presence in coal of certain "ions." On the whole the book does not impress the reviewer as giving the student of domestic science much idea of the close relation between the principles of chemistry and the proper and economic use of foods and industrial products.

THE COPPER HANDBOOK. Vol. IX, 9th Edition. By Horace J. Stevens. Cloth, 8 vo. 1,628 pages. Price, $5.00 postpaid. Horace J. Stevens, Houghton, Mich.

This work, which has become a standard authority on the subject for the entire globe, has, in its latest edition, considerably more than a million words, and, in addition to the miscellaneous chapters, lists and describes no less than 7,751 copper mines and copper mining companies, in all parts of the world. These descriptions range from two or three lines in the case of companies that have recently gone out of existence to sixteen pages in the case of one of the largest mines —a mine, by the way, that employs some seven thousand men, and has paid dividends of considerably more than a hundred million dollars. The mine descriptions are the same as in the preceding volume, except that upwards of eight hundred new titles have been added, covering descriptions not contained in any previous edition. The chapter of statistics contains upwards of forty tables, and treats of copper from almost every conceivable standpoint. This has been fully revised and brought as nearly as possible up to date.

The miscellaneous chapters of the book, twenty-four in number, treat of the history, chemistry, mineralogy, metallurgy and use of copper. This section of the book also has chapters devoted to substitutes, alloys, brands and grades, and a copious glossary.

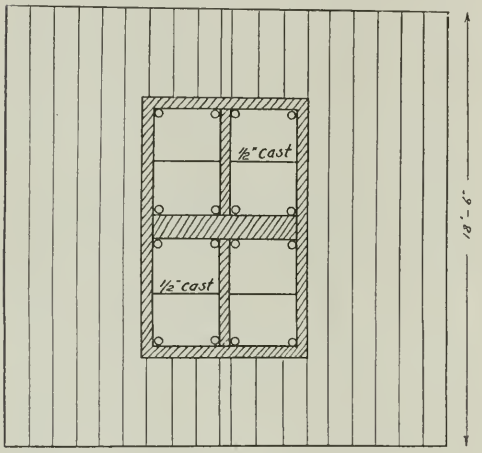
Anyone interested in the subject of copper, as metallurgist, chemist, consumer or investor in stocks, should have a copy of the Copper Handbook. It is a standard work well worth the price.

METALLURGY.

GUADALUPE QUICKSILVER WORKS.*

By COURTENAY DE KALB.

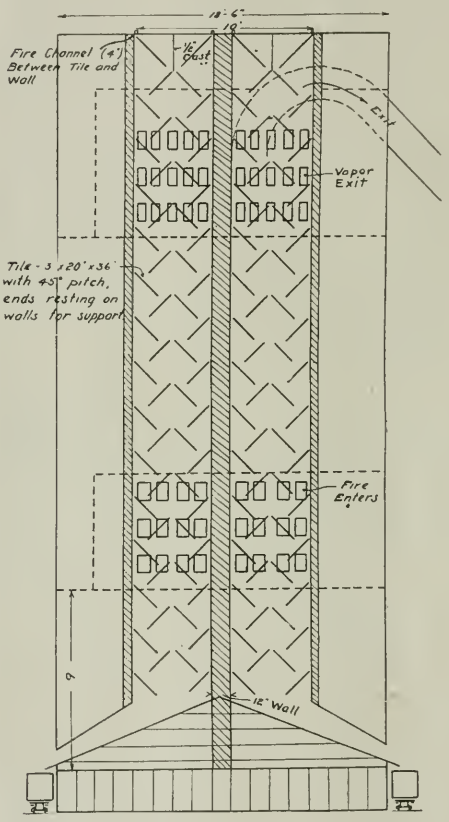
Cinnabar was first mined in Santa Clara County, California, in 1824, by Antonio Sunol and Luis Chaboya. The property was originally called the Chaboya, but was later christened the New Almaden, appropriately perpetuating in America the fame of the great quicksilver mine of Spain. A short distance from the New Almaden property is the Guadalupe, which also has had a record of large production from the early days of mining in the state. Extensive operations were



Transverse Section of Litchfield Furnace.

begun here in 1855 by the Santa Clara Mining Association of Baltimore, and continued until 1875, when the property was sold to the Guadalupe Mining Company of California, which conducted the work with falling fortunes until 1886. It then remained idle until 1890, when the Century Mining Co. was organized by H. C. Davey, later taking the name of the New Guadalupe Mining Co., and a new period of productivity was inaugurated that has lasted to the present. In its palmy days the mine yielded as much as 1,900 flasks of quicksilver per month. This was when high-grade ore was available. The output is now 200 flasks, of 75 lbs. each, per month, the recovery averaging 2 per cent of the total ore treated.

The original main shaft was sunk in the valley close to the channel of Capitancillos Creek, and the workings reached a depth of about 1,100 ft. Much difficulty was experienced with water in the mine, and the decreasing tenor of the ore rendered economical mining impossible. The hills on both sides of the creek were also extensively prospected and considerable ore found. The deposit now worked is at a depth of about 700 ft. under the hills on the north side of the creek,



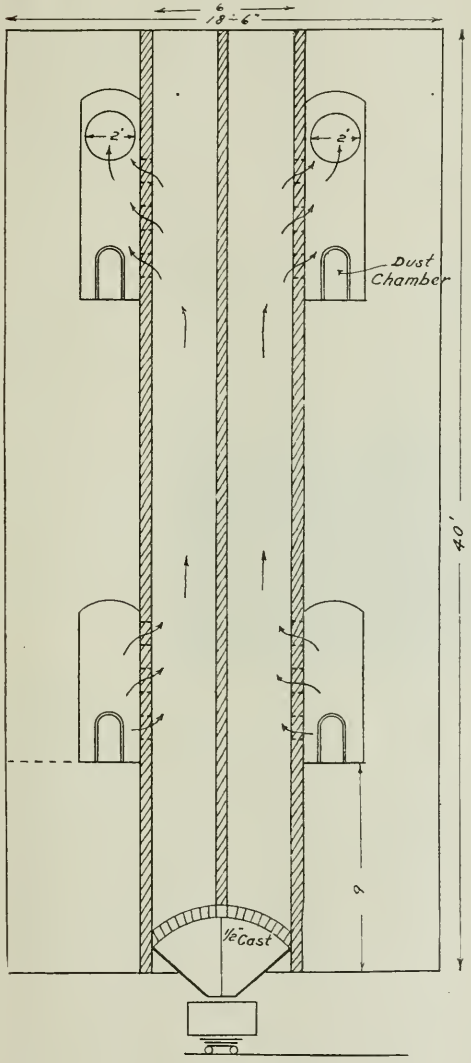
Longitudinal Section of Litchfield Furnace, Great Western Quick Silver Mine.

and is reached by an adit over 2,000 ft. long. The cinnabar occurs in serpentine in proximity to intrusive masses of rhyolite. The exact content of the ore is unknown, but the extraction is quite complete. Of the total recovery as much as 63 per cent is obtained as metal direct from the condensers, the remainder being extracted from the soot. This result is probably due in large part to the fact that oil is now used for fuel, and the combustion being quite perfect the amount of soot produced is small. The soot carries mercury with

*Mining and Scientific Press.

it, and the reduction of the quantity of soot necessarily lessens the percentage of the metal which fails to condense and drain from the condensers.

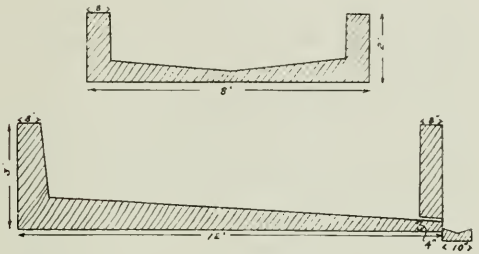
The ore on coming to the works is crushed in a Hendy rock-breaker, 8 by 12 ins., the feeder consisting of a short trommel, thus avoiding the re-crushing of material already fine enough for the furnaces. An



Plan of Litchfield Furnace.

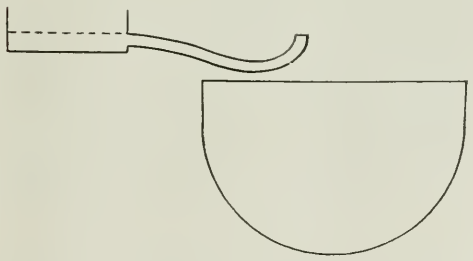
elevator takes the product to a screen with 1½-in. holes, dividing it into coarse and fine grades which are distilled in separate furnaces. The average size of the coarse ore treated is 3 inches.

The distillation takes place in modified Litchfield furnaces. The accompanying drawing shows a typical Litchfield furnace, such as is used at the Great Western Quicksilver Co.'s mines in Lake County, California. It consists of tall distillation chambers with inclined tiles placed so as to cause the ore to slide downward in a zig-zag from the feed-hopper at the top to the base where it is drawn off into cars. The double distillation chambers are paralleled with chambers in which fire is maintained, the heated gases passing through ports from these. The Litchfield furnace used at the Guadalupe mine differs in important details. It has eight distillation-chambers or "channels," 40 ft. high, and 3 by 6 ft. each, in horizontal section, the block be-



Soot Table.

ing 30 by 18 ft. in plan. The upper part of each channel contains a constriction called a "throat," which the ore completely fills as it passes through. Above the throat is a dryer, consisting of a prolongation upward of the channel, fitted with additional inclined tiles. This device is an improvement patented by H. C. Davey. An auxiliary fire is used to effect the drying in this upper shelf-furnace. The condensers at the Guadalupe works are brick chambers, two in number, placed tandem. They are of red brick, and are 12 by 40 ft. in plan and 20 ft. high. From these the fume



Mercury Siphon and Kettle.

passes through a series of brick flues, 2 by 3 ft., expanding into smaller condensing chambers at frequent intervals. The total travel of the fume from the retort-furnaces to the stack is 3,000 lineal feet, and draft is induced by a 6-ft. fan placed at the entrance to the stack. The fan is driven by a 2-hp. motor.

There are two blocks of furnaces, the fine-ore furnace having a capacity of 30 tons per diem, while the

coarse-ore block treats 12 tons. Calcined ore is drawn off every hour. The oil burned amounts to 1 bbl. to each 10 tons of ore distilled. The soot was formerly distilled in iron retorts, but is now treated on concrete "soot-tables" 12 ft. long by 8 ft. wide, made in the form of a broad shallow V-shaped trough, inclined from the head toward the discharge end. The soot is placed on the sloping floor of this table, where it is hoed with ordinary garden hoes at frequent intervals. The metal collects into globules of sufficient size to run out of the soot, which is left undisturbed a few hours after each hoeing. In this way the extraction is so perfect that but little quicksilver remains, and the soot is then returned to the ore fed into the top of the distilling furnaces. Cement-lined brick channels lead from all the condensers and from the soot-tables to cast-iron quicksilver wells of 3-ton capacity, which are kept locked. Above the wells are boxes which receive the mercury before it passes into this final receptacle. These boxes are partly filled with water, and a "goose-neck" pipe leads from the bottom of each, overhanging the well. Thus the quicksilver is freed from dirt and grease, and automatically discharges as it accumulates.

Labor in the works consists of three men to each shift of eight hours. Sixty men in all are employed, above and below ground. Extensive improvements are under way, including the installation of a 125-hp. Pelton wheel, to take water under a head of 734 ft. This will drive air-compressors for drilling in the mine, in addition to operating the surface works. At the present time 75 hp. is consumed, this being developed by a water-wheel.

The relation between volatile matter and efficiency in coals used in house-heating boilers is of particular interest to people using coal from the central part of the country, as in Indiana, Illinois and Iowa, as these coals contain much volatile matter. The volatile content of the coals tested recently by the United States Geological Survey ranged from 18 to 44 per cent, and as the volatile matter increases the efficiency decreases, for much of the volatile passes out of the stack unconsumed. The efficiency is 60 per cent with coal containing the least volatile matter, but is reduced to 47 per cent for coal having the greatest amount.

Chrome-nickel steels are usually made in both high and low-carbon types. The former is used for oil-hardened gears and springs, and the latter for general structural purposes, such as axles, shafts, forged parts and for case-hardened gears in automobiles. The high-carbon type contains about 0.5 per cent carbon and the low-carbon type 0.25. The nickel varies from 2 to 3.5 per cent and the chromium from 1 to 15. These steels present difficulties in heat-treatment, forging and machining.

ELIMINATION OF SMELTER FUME AT THE PLANT OF THE UNITED STATES SMELTING CO., MIDVALE, UTAH.*

By LEROY A. PALMER.

Early in 1905 a legal battle was commenced between the farmers of Salt Lake Valley and the four smelters at Murray and Bingham Junction, Utah. This fight was carried on for nearly 3 years and resulted in an injunction from the federal court restraining three of them,† from treating ores containing arsenic or sulphur above a certain percentage, the limits set being such as to force all three of the plants to close down immediately. One of the three has been dismantled and sold to the International Smelting and Refining Co. for its plant which is building at Tooele, Utah; another has been abandoned and is falling to pieces; the third, that of the United States Smelting Co., had set its chemists to work before the injunction was issued to solve the problem presented by the gases. In 8 months after the shut-down, this third company had convinced the court that the lead ores ruled against could be treated without detriment to vegetation or live stock, and secured a modification of the ruling which permitted them to start the lead furnaces. Further experiments have now solved the problem of the gases from the copper furnaces and secured a second modification which will permit these being operated so soon as the necessary equipment can be installed. The successful outcome of these experiments marks one of the most important events in recent metallurgical history, for not only have the furnaces been permitted to operate, but arsenic, a valuable by-product, is being recovered, which heretofore escaped from the stack and worked harm to the surrounding country.

The results are accomplished by a system of neutralizing the gases and bagging all of them so that almost no solid matter escapes from the stack. The illustration, Fig. 1, is from a photograph taken when the lead furnaces were in full blast, and shows conclusively that practically no smelter smoke issues from the stack. This is the only smelter in the world which has successfully bagged all of its gases, amounting to 350,000 cubic feet per minute, without working material injury to the bags or discharging into the atmosphere substances which may or may not be injurious to vegetation. It has been by no means uncommon to bag the sulphur dioxide SO_2 gases from lead blast furnaces, but the gases from the roasting furnaces which contain sulphur trioxide SO_3 have presented a problem heretofore unsolved. The SO_3 gas on reaching the atmosphere is converted into sulphuric acid by the absorption of moisture and naturally works injury where it falls. Efforts to bag these gases have been unsuccessful, as the SO_3 is highly corrosive and rapidly destroys the bags. Lack of this corrosion serves as a test of the gases, in a way, since the smelterman

†The fourth effected a compromise by agreeing to pay the farmers an annual indemnity.

*Mines and Minerals, March, 1910.

knows that if the gases passing through his bags do not damage them, they contain nothing which will be destructive to vegetation.

Aside from the special features mentioned, the plant is a thoroughly equipped modern lead smelter. The ores treated are both custom ores and those produced from the company's own mines, the Old Jordan and Galena, of Bingham; the Centennial-Eureka, Utah; and the Richmond-Eureka, of Eureka, Nev.

Sampling Mill.—The shipper to this plant has the choice of two custom samplers which are convenient, or the company's sampler. The ore is delivered to the sampler from a standard-gauge railroad trestle and dumped into a hopper-bottom bin. From this bin it is fed through two hand-operated gates to a 10" x 20" Blake crusher which crushes to pass a 2½-inch ring, and discharges the product on to a conveyer running on a slight incline to a series of four Snyder samplers. The Snyder sampler is a vertical saucer-shaped device with one or more segments cut from it. As the saucer revolves the sample cut out passes through the segments, while the discard that strikes against the solid part falls back and is discharged elsewhere. The first sampler makes a one-fourth cut, sample and discard going to separate elevators. These elevators are set on solid timber foundations with the boots above the floor so that in case one chokes it may be quickly cleaned by opening a door and allowing the ore to run out on the floor. The discard is discharged outside of the mill to the railroad cars. The sample discharges from the elevator to a No. 6D Gates gyratory crusher, which breaks it to 1¼ inches, passing which a second cut of one-fifth is made and the sample passed on to a set of 14" x 28" Davis rolls, crushing to ⅞ inch, after which a sample cut of one-sixth is made. This last sample goes to a set of 14" x 12" Colorado Iron Works rolls, which crush to ⅜ inch, giving a product from which the final cut of one-sixth is made, thus furnishing a sample 1/720 of the entire lot. All sample discards are sent to the discard elevator. A sample obtained is finished in the bucking room on a set of laboratory rolls and a Braun pulverizer. A 50-horsepower General Electric motor wound for 440 volts drives the sampling mill.

The sampled ore is taken from the sampling mill to the bins provided for it, the coarse-ore bins being convenient to the blast furnaces and the fine adjacent to the roasters.

Roasters.—All fine ore is sintered in the roasters before treatment in the blast furnaces. For some time the fine oxidized ores were briquetted but this practice has been abandoned, and all fine material, whether ore or flue dust, is now sintered.

At the roaster the ore is bedded as in the usual blast-furnace practice in a series of bins of 1,000 tons capacity each, the ore mixture being arranged so as to have as nearly as possible a content of 18 per cent sulphur. This system of bedding is being abandoned and in the future all ore will be bedded in the charging cars. One reason for this change is that, with the heretofore customary method of bedding, an absolutely uniform mixture is not obtained in the ore taken from the bin when first opened and when almost empty. More important than this is the saving in labor when using cars, and the fact that if a mixture is found unfavorable it can be immediately changed.

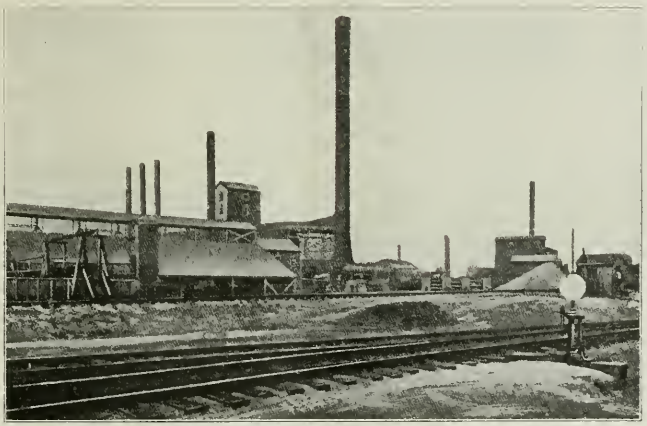


Fig. 1—Midvale Smelter, Lead Furnaces in Full Blast.

The bedded ore is loaded into cars of 18 cubic feet capacity, which are run directly into the bins, and when loaded trammed to a Smith concrete mixer. Water is added to make a mass containing about 10 per cent moisture, or sufficient to mass the ore so it will stand the handling to which it is subjected. The mixer discharges the ore continuously on to a 14-inch rubber-belt conveyer running on an angle of 30 degrees, which dumps into the roaster bins, from which the ore is trammed to the roasters.

Pot Roasters.—These roasters, known locally as the converter roasters, or pot roasters, now represent the

evolution of an idea recently worked out at this plant, and while several minor changes have been made from time to time, the principle involved has not been altered from the first. Fig. 2 shows a cross-section of the roaster house.

Each roaster consists of a square firebox, *a*, 6½ ft. x 6½ ft. x 5 ft., with a grate of 1-inch iron plate in which holes are drilled ½ inch in diameter and on 1½-inch centers. Back of each roaster is a 10-inch air line

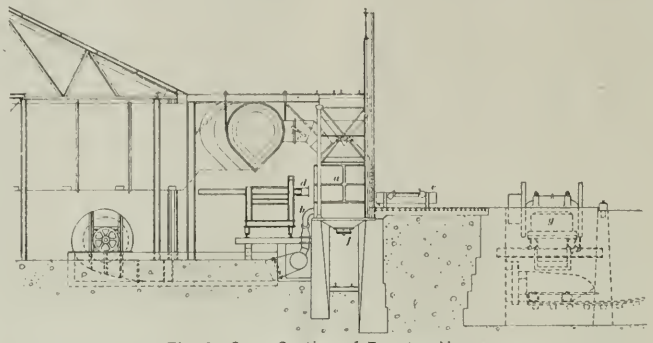


Fig. 2—Cross-Section of Roaster House.

dividing into two 7-inch lines *b*, which enter the roaster below the grate at points one-fourth of its width from each wall. The fume from each furnace passes through a 24-inch elbow *c* to a 6-foot balloon flue, which discharges midway of its length to a similar flue 8 feet in diameter. The entire front of the firebox, best shown in Fig. 3, can be opened, the upper portion swinging up and back on hinges and the lower being counterbalanced and working in guides.

About midway of the line of 19 roasters, four of which are shown in Fig. 3, is the priming furnace. This is merely a brick stack built out of an old roaster in which a fire of slack coal and coke breeze is maintained. When it is desired to start a roaster, a bed of live coals from this primer is spread over a layer of fine roasted material and the blast turned on moderately. The cars from the bins then dump their loads into a hopper above the roaster and the ore is fed slowly on to the bed of live coals. The charge is carefully spread and the blast watched closely until the whole mass has begun to burn evenly when the contents of the hopper are dumped on bodily and the blast turned on full force. It is essential that the charge be started carefully to avoid the formation of blowholes, but when properly started little attention is required beyond watching for and plugging an occasional blowhole. A charge roasts in from 3½ to 8 hours, according to its composition, and each roaster has an average daily capacity of from 19 to 20 tons. By this roasting system, from 72 to 75 per cent of the sulphur is oxidized, and as high as 77 per cent has been eliminated, leaving the roast with about 5 per cent sulphur. About 4 per cent of the lead is volatilized in the process, but from 1⅛ to 2 per cent is recovered in the flues and the remainder in the bag house, there being absolutely no lead loss from the stack.

When the charge is roasted to the desired stage, the blast is shut off, the front of the furnace opened and the electric ram *d*, Fig. 2, brought into use. This ram is merely an I beam which can be moved by a motor-driven rack and pinion, mounted on a truck. When it is desired to discharge the roasted button, the truck is brought behind and clamped to the furnace by heavy hooks with turnbuckles. The ram is then put in motion and the button pushed bodily into a large tray or "steel boat," *e*, placed to receive it. One can readily understand that the charge must be carefully sintered to withstand such treatment without breaking. A hopper *f* below each roaster catches any dust that may fall through the grate, and once a week this is cleaned out into cars that run in a tunnel underneath, and is retreated.

The tray containing the button is picked up by a 20-ton Gantry crane and carried to the end of the roasters

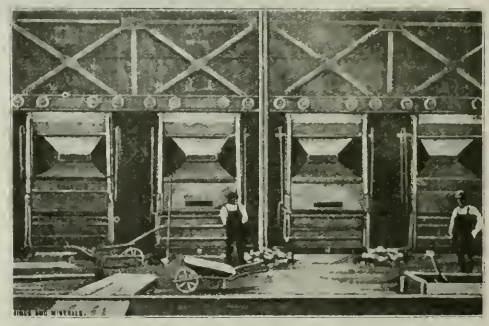


Fig. 3—Front of Pot Roasters.

where it is broken by dropping it to the ground. The larger pieces are picked up in grappling tongs handled by the crane, and smaller pieces by hand, all being fed to the 30" x 40" Blake crusher *g* which breaks the sinter to a maximum size of 5 inches and discharges it to a self-dumping skip of 76 cubic feet capacity. The skip is hauled up a 45-degree incline and its contents dumped into railroad cars which are hauled to the blast-furnace bins.

(To be continued.)

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

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NOTES AND COMMENTS.

Purchase of Coal Under Specifications.

The opening article of the first issue of THE CHEMICAL ENGINEER was devoted to this important subject, and it is one which we have touched on many times since. We have mentioned frequently the value to the consumer of testing the quality of his coal and of insisting that it comes up to the guarantee of the seller. Since the first number of THE CHEMICAL ENGINEER the subject received much more general attention than it did at that time and the technical papers now generally urge it.

Practically all power plant men today acknowledge that the proper way to purchase coal is under some form of specifications. Just at present, however, the bone of contention is just what should these specifications be and how should they be drawn up. Numerous scientific bodies have appointed committees to devise specifications for the purchase of coal. The subject is one of such diversity that it does not seem probable that any set of so-called "standard specifications" can be drawn up for the simple reason that the coal to give satisfaction must be of such a nature that the fire box of the boiler is suited to its economic combustion. Not only this, but in certain localities the coal mined would not fill the specifications drawn to suit another locality, while the consumer would obtain much more value for his money from the local coal than from that brought in from a distance.

The common method employed by those who purchase coal is to specify that the latter shall contain at least a certain number of British thermal units per pound, or else that the ash shall not rise higher than a certain fixed percentage. Coal operators generally object to these specifications on the ground that it is unfair to them to penalize the seller for all coal which falls below the fixed number of British thermal units per pound, or rises above the given per cent of ash, while they receive no credit when the coal is very much better than that called for in the specifications. The sellers declare that if they are penalized for poor coal they should be premiumed for good coal, since, while the customer may lose by the bad coal, he also gains by the good coal. Certain departments of the National Government and a few other large users of coal have overcome this objection, to some extent, by purchasing under a sliding scale, by which the shipper gets to some extent credit for the excess over and above the consumer's specifications.

Another objection which is raised to fixed specifications is that they do not allow competitive bidding between coals of different calorific value, and that in many cases a low grade coal is shut out which would be very much cheaper to the consumer, even when its low thermal efficiency is considered, than the higher grade coal called for by the specifications.

From the use of any set of specifications which calls for simply a certain minimum number of British thermal units per pound, or a certain maximum percentage of ash, the consumer is likely to meet with the difficulty that much coal could be furnished under them, which would be unsatisfactory for use under his particular type of boilers and that a coal of very much lower thermal value than that specified would give much better results than that which is asked for. For instance, gas slack is often of much higher thermal value than a good quality of steam coal. Its price is cheaper, but its heating value under the average boiler is nowhere near as great in spite of a greater number of British thermal units. So that the substitution of gas coal for steam coal would in many instances give the consumer coal of higher thermal value than the one asked for, and yet coal which would be much less satisfactory under a boiler. At the same time it is unquestionable that the most satisfactory method of drawing specifications is to base these upon the British thermal units per pound.

In every successful set of specifications there must be clauses which define the nature of the coal desired and in some instances even its size. The requirements as to volatable combustible matter, the size of the coal particles, etc., will in all except rare cases restrict the dealer to furnishing coal suitable to the boiler's use. All specifications as to the thermal value of the coal are usually drawn to require that the coal shall have a given number of British thermal units per pound. This, as we have said, is objected to by the producer, on the ground that he receives no bonus for coal which is better than that which is required by the specifications. In buying a pound of coal the purchaser really buys potential energy which he wishes later to transfer to cinetic energy. Would it not be better therefore instead of purchasing coal by units of weight to purchase it by potential units such as the British thermal unit; in other words, instead of buying a pound or a ton of coal, buy such a quantity of coal as will contain a given number of British thermal units, and leave it to the dealer to supply the actual weight of coal necessary for this. The British thermal unit unfortunately is rather small for such a unit. Some other, however, could easily be employed. For example, suppose we agreed upon a unit "*M*" equal to one mil-

lion thermal units. This would be represented by about 75 pounds of good semi-bituminous coal. The shipper could then quote the consumer on coal, falling between given limits as to volatable combustible matter, a price of 4.5 cents per "M." If his coal contained 13,000 British thermal units per pound, the seller would need to supply the purchaser with 77 pounds of coal for each "M" purchased. The substitution of a cheaper gas slack of a still higher thermal value but not suited to the boilers of the consumer, would be negatived by the limits prescribed as to volatable combustible matter.

It would probably be necessary in purchasing coal by such a system to make some arrangement as to the ash, due to the fact that the cost of stoking the coal depends to some extent upon the ash; also that the ash itself must be removed from the boiler plant, and if the latter is located in a city it would be necessary to carry this ash a considerable distance. Furthermore, the ash always carries away with it some unconsumed carbon, and the more ash present the more combustible is lost in this way. The specifications therefore could be made to read so that the seller should compensate the purchaser for any excess ash which he has to handle. This could be determined by averaging the ash analyses. No standard specifications could be drawn which would fix definitely the penalty for high ash, because in the manufacturing plant situated in the mountain where ash could be dumped close to the boiler plant the cost of handling ash would be very slight, while with the plant in the city it might be necessary to either cart or freight these ashes to a point at a distance from the boilers.

CHEMICAL SOCIETIES.

San Francisco Meetlng American Chemical Society, July 12-15, 1910.

The summer meeting of the American Chemical Society, to be held in San Francisco, July 12-15, 1910, promises to be one of the pleasantest outings ever enjoyed by the members of the Society. A special train made up of the Santa Fe's finest equipment will leave Chicago on the evening of July 4, arriving at Colorado Springs on the morning of July 6. About six hours will be allowed for a trip to Manitou, the Garden of the Gods or to the top of Pike's Peak. Leaving about 1 o'clock the train will reach Adamana on July 7, and a half day will be spent in a visit to the Petrified Forests, two of which, and possibly three, may be examined. Leaving Adamana that night the party will arrive at the Grand Canyon of the Colorado on the morning of July 8, where the day will be spent. Leaving the Grand Canyon that evening the train will arrive at Redlands and Riverside, California, the following afternoon and about two hours and a half will be given to the semi-tropical scenery of each of these two cities. Sunday, July 10, will be spent at Los Angeles, leaving there in the evening and arriving at Lang, California, on the following morning. At Lang, the borax mines will be visited on invitation of Mr. S. T. Mathor of the Thorkildsen-Mather Company, where the party will be their guests until about 1:30 o'clock, when the train will leave for Santa Barbara, giving about five hours in that unequalled seaside resort. During the night the train will leave for San Francisco via the coast route of the Southern Pacific, probably reaching this city about 12 o'clock of the 12th.

The meeting will follow, and the society will be entertained by the California section. The tentative program includes: First, a steamer trip around the bay and out through the Golden Gate; second, a trip to the top of Mt. Tamalpias and to the Muir Woods, the first giving us an extensive view of the ocean, the bay and the surrounding mountains and hills, while the second contains fine specimens of the coast redwood (soquoia Sempervirons); third, an excursion on the Ocean Shore Railway to Poscadero, with a possible return via the Santa Clara Valley; fourth, an excursion to the vineyards and wineries of the Italian-Swiss colonies in Sonoma County; fifth, a visit to the University, with a possible automobile trip through the orchards of the Santa Clara valley; seventh, a camping out trip for one night and parts of two days into the Big Basin, the State Park, where some of the biggest redwoods are to be seen; also it is hoped to visit some of the local manufacturing plants.

Following the meeting the party will dissolve as a whole, returning as they desire, either via the smelters in Utah and Colorado, via the beautiful scenery of the Canadian Pacific, or via the National Yellowstone Park.

Unusually low rates have been obtained from Chicago, namely, $62.50 for the round trip from that city, with $15.00 extra if the party returns via the northern routes. There will be $0.50 extra railway fare on the side trip to the Grand Canyon. The berth rate from Chicago to San Francisco will be $14.00, with an additional charge for the four extra days in transit in lieu of hotel expenses, as the Pullmans will be used throughout the trip. This additional charge will approximate $7.00 on the berth rate.

The Puget Sound section are hoping that a considerable number of the members may decide to return via Seattle and if a party can be formed they will make every effort to show us their own delightful surroundings.

In view of the efforts that are being made by the California members and of the unusual attractions of the trip, it is hoped that a special effort will be made by Eastern members to be present at the meeting. Reservations for the special train will be made in the order for their receipt. Any members of allied societies going West at this time who may wish to share in the privileges of the special train should address the Secretary, Charles L. Parsons, New Hampshire College, Durham, N. H.

INDUSTRIAL AND PLANT NEWS.

Aluminum Wire.—An order for 1,500,000 pounds of aluminum wire was recently placed with the Aluminum Company of America, of Pittsburg, by the Hydro-Electric Commission, of Ontario, Canada. The wire is to be used for the transmission of electric current from Niagara and to supply the city of Toronto and other small towns in that vicinity. The wire will be drawn at the works of the Aluminum Company in Niagara Falls and Massena, Quebec.

Coke.—The International Harvester Company has bought $1,000,000 worth of coal lands along the route of the New Harlan-Pineville Railway in Kentucky, and will establish coke ovens.

Ferro-Silicon.—The Susquehanna Smelting Company has decided to close its electric furnace plant for the manufacture of ferro-silicon in Lockport, N. Y., on account of the continued unsatisfactory condition of the ferro-silicon market. Ferro-silicon is now manufactured on a large scale in this country by the Electro-Metallurgical Company (with works in Kanawha Falls, W. Va., and Niagara Falls, N. Y.) A Canadian company is operating at Welland. Metallic silicon is made by the Carborundum Company.

Glue.—The Manitoba Glue Co., Winnipeg, Man., will erect a plant at St. Vital, four miles from Winnipeg. The company has been organized with James Powers, Pres.; H. P. Bilodeau, Vice-Pres., and F. J. G. McArthur, Secy.-Treas. Head office, Winnipeg.

Iron.—The Utah Iron Co., Salt Lake City, Utah, has filed articles of incorporation, the capital stock authorized being $3,000,000. It proposes to erect an iron and steel plant, and owns about 600 acres of iron ore land. Thomas F. Kelly, Chicago, is president; Patrick Ryan, Salt Lake City, vice-president; Eugene M. Kelly, Chicago, treasurer; Edward McGurrin, Salt Lake City, secretary.

Radium.—It is announced by a British consul that a radium factory is being started at Lidingö, one of the suburbs of Stockholm, Sweden. The company hopes to have a factory which will employ about 120 men ready in a few months, and expects to produce 4½ grams of radium per year.

Steel.—Fifty years ago, on April 7, 1860, what is now the Bethlehem Steel Company began its active existence. This anniversary was celebrated, Thursday afternoon, April 7, 1910, in befitting manner by the blowing in of one of the most modern blast furnaces in existence, at South Bethlehem. John Fritz, the world-famous iron master, who was so long and prominently identified with the plant, applied the torch which put the furnace in operation.

The new furnace, which is 90 x 22 feet in dimensions, is the first of a battery of furnaces which President C. M. Schwab is planning to erect. It will produce nearly 15,000 tons of pig iron per month. When the other blast furnaces are completed the company will have seven in active use, which will be able to produce more than 1,000,000 tons of iron a year.

Sugar Refining Machinery.—It is announced at Hackensack, N. J., that the Gregg Company, limited, of Newburgh, N. Y., has bought a 50-acre site in Lodi borough, near the Hackensack boundary line, on which it will build a plant to cost $500,000. This concern has outgrown its plant in Newburgh, where it manufactured sugar refining machinery and sugar cane car equipment. The Gregg Company will employ about 500 persons.

Sulphuric Acid.—The firm of C. F. & G. B. Binder, Atlanta, Ga., have just completed for the Standard Guano and Chemical Manufacturing Co., New Orleans, La., one of the largest and most up-to-date sulphuric acid plants in the South. Everything in connection with the new plant is modern and constructed with a view to handling materials in the most economical manner. The pyrites burners are 60 in number, and are of unusually large size. They are arranged in two sets of 30 burners each, each set being connected with a separate "niter oven" of the most improved type. The acid chambers are built to produce a minimum of 600 tons of 50° Bé acid per week, and are fitted with a special modification of the water-spray system. The Glover and Gay Lussac towers are of steel frame construction and packed in a manner which is original with the constructors. The work of erecting this plant was begun about the first of the year, and in the latter part of February was producing enough acid to supply the various departments of the company and permit the shipment of large quantities to other consumers.

Sulphuric Acid.—Work on the $1,000,000 acid plant at the Liebig Works, Roosevelt, N. J., is about completed and a number of the departments are now in operation. This plant is considered one of the largest in the world, and will furnish acid, which will be shipped in tank barges, to many different plants.

Wire.—Ground was broken last week by the Cambria Steel Company for the new rod and wire mill, to be added to the Johnstown, Pa., plant. The new mill will be one of the largest in the country, with a capacity of 400 tons a day. The company has completed the installation of a new 8-inch mill and is building a semi-continuous 8 and 12-inch mill.

At the Cambria plant four additional 50-ton open hearth furnaces and a new 18-inch continuous billet mill with a capacity of 2,000 tons a day will be erected. Extensions will also be made in the splice bar mill.

Wood Pulp.—That the province of Quebec will, in the near future, prohibit the exportation of pulp wood, cut on the crown lands of the province, to the United States, was announced in the Legislature, April 12th, by Premier Gouin.

Zinc.—The property of the Lanyon Zinc Co. will be sold at Sheriff's sale, April 11, at 10 a. m. at the court house at Iola, Mo. Acting for bondholders, the Trust Co. of America, New York, obtained a judgment for about $2,225,000 against the company and an order of foreclosure. The property includes all rights, leases, contracts, franchises, stocks and plants. The intimation is given that interested parties will buy in the plants and reorganize the company.

RECENT INVENTIONS.

The following recent patents have been reported for the Chemical Engineer by C. L. Parker, solicitor of chemical patents, McGill Building, Washington, D. C.

947,789. *Treatment of Pyritic Copper and Copper-Nickel Ores.* James T. Carrick, Johannesburg, Transvaal. February 1, 1910.

947,791. Process of *Recovering Nickel and Copper from Ores* and Mattes. Adolphe Chalas, Philadelphia, Pa., February 1, 1910.

947,795. Method of Producing *Fertilizers.* Leonard R. Coates, Baltimore, Md., February 1, 1910.

947,796. *Fertilizer* and Method of Producing Same. Leonard R. Coates, Baltimore, Md., February 1, 1910.

947,798. Method of Producing *Fertilizers.* Leonard R. Coates, Baltimore, Md., February 1, 1910.

947,831. Manufacture of *Zinc.* Oscar Loiseau, Sclaigneaux, Belgium, February 1, 1910.

947,957. Process of *Recovering Fine Gold.* James H. Alling, San Francisco, Cal., February 1, 1910.

This is a method of recovering gold which consists in mixing the gold-bearing material with a solution of a mercury salt, causing the mixture to flow between the upper and lower

electrodes and collecting the resulting amalgam at the bottom of the stream of the mixture

947,983. Purifying *Tantalum*. Ezechiel Weintraub, Schenectady, N. Y., February 1, 1910.

948,015. Manufacture of *Lime and Gas*. George G. Floyd, Kirkwood, Mo., February 1, 1910.

948,158. Process of *Utilizing Nitrous Gases*. Kristian Birkeland, Christiania, Norway, February 1, 1910.

948,372. Process for *Producing Oxides of Nitrogen from the Air*. Francis I. du Pont, Wilmington, Del., February 8, 1910.

This is a method of producing oxides of nitrogen from air, which consists in subjecting air in contact with a non-conducting cooling surface to the action of a moving arc extending between electrodes longitudinally of the non-conducting surface and against said cooling surface, whereby the high heating by the arc is immediately and rapidly reduced.

948,383. *Artificial Leather*. John J. C. Smith, Passaic, N. J. February 8, 1910.

948,512. Method of *Treating Cans of Alkaline Storage Batteries*. Thomas A. Edison, Llewellyn Park, Orange, N. J., February 8, 1910.

The process consists in treating the cans or receptacles of alkaline storage batteries, by applying a microscopic film of non-saponifiable oil to the exterior thereof for the prevention of the formation of crystals of the alkaline salt on the exterior of the receptacles.

948,515. Process of *Treating Antimony Ores*. Henri L. Herreuschmidt, Paris, France. February 8, 1910.

948,681. *Electrolytic Separation of Metal*. Edwin M. Chance, Philadelphia, and Eleanor Kent, Lansdowne, Pa., February 8, 1910.

948,726. Method of *Absorbing Dilute Nitrous Gases*. Birger F. Halvorsen, Christiania, Norway. February 8, 1910.

This is a method of absorbing hot nitrous gases, which comprises conducting said gases while hot into finely divided dry lime.

948,710. Process for Obtaining *Zinc from Zinciferous Materials*. Hermann Pape, Hamburg-Billwarder, Germany. February 8, 1910.

948,790. *Explosive*. Anton Mikolajczak, Kastrop, Germany. February 8, 1910.

The explosive contains dinitro-glycerine and absorbent material.

948,812. *Artificial Fuel* and Process for Making the Same. Charles F. Bonhack, New York, N. Y. February 8, 1910.

948,811. *Paint and Varnish Remover*. Mayer Daxe, New York, N. Y. February 8, 1910.

948,827. *Treatment of Ores* for the Extraction of Metals Therefrom. Hugues Rosalt, Paris, France. February 8, 1910.

948,833. *Composition for Cleaning Boilers*. Eugene Vezie, Washington, Pa., February 8, 1910.

948,917. *Catalytic* and Process of Making Same. Theodore J. Wrampelmeier, Berkeley, Cal. February 8, 1910.

The catalytic consists of finely divided pyrites cinder held or bound together by a binding agent capable of exercising catalytic action.

949,002. Process for the *Separation of Combined Minerals*. Alexander S. Ramage, Newark, N. J. February 15, 1910.

949,003. Process of *Producing Electrolytic Copper*. Alexander S. Ramage, Newark, N. J. February 15, 1910.

949,004. Method of *Recovering Iron from Ores and Preparing Iron Alloys*. Alexander S. Ramage, Newark, N. J. February 15, 1910.

949,010. Manufacture of *Incandescent Bodies for Gas-Lights*. Max von Unruh, Charlottenburg, Germany. February 15, 1910.

949,058. Process for the *Treatment of Silver-Nickel-Cobalt-Arsentic Ores*. Camillo C. Cito, Irvington, N. J. February 15, 1910.

949,058. Process for the *Treatment of Silver-Nickel-Cobalt-Arsentic Ores*. Camillo C. Cito, Irvington, N. J. February 15, 1910.

949,324. Process of *Treating Spent Alkaline Pulping Liquors*. William J. Hough, Toledo, Ohio, February 15, 1910.

949,412. *Cementing Material* and Method of Making the Same. Hugh Rodman, Pittsburg, Pa. February 15, 1910.

949,474. Process of *Refining Iron*. Frederick W. Hawkins and George F. Key, Detroit, Mich., February 15, 1910.

This is a process of refining iron which consists in first eliminating a portion of the oxidizable impurities in the molten metal while in a divided state, by a process of oxidation, in the atomizing or breaking up the molten mass into minute particles and scattering the same to complete the oxidation, and then percolating the separate particle through a bed of comminuted material having a chemical affinity for the remaining impurities.

949,500. Process of *Bluing Iron or Steel Articles*. Morgan Rees, Follansbee, W. Va. February 15, 1910.

949,575. Method of *Treating Iron or Steel Articles*. Henry Howard, Boston, Mass. February 15, 1910.

949,837. *Compound Metal* and Process of Making the Same. William M. Page, Philadelphia, Pa. February 22, 1910.

949,924. Process of Manufacturing *Concrete Compositions*. James W. Adams, Curtis, Nebr. February 22, 1910.

949,954. *Reduction of Organic Substances*. Fred Bedford, Sleaford, England, February 22, 1910.

949,980. Composition for *Softening Steel*. George F. Diez, New York, N. Y. February 22, 1910.

The composition is an alkaline earth base, caustic potash and iron.

949,988. *Treated Carbon* and the Method of Producing It. Peter J. Mulvey, Schenectady, N. Y. February 22, 1910.

950,035. Process of *Treating Sugar Beets*. Moriz Weinrich, Yonkers, N. Y., February 22, 1910.

950,095. Composition for Converting *Iron into Steel*. George F. Diez, New York, N. Y. February 22, 1910.

950,115. Process of *Removing Tin from Scrap*. Charles J. Reed, Philadelphia, Pa.

This is a process of separating metals which consists in heating and agitating the mixture with subdivided magnetite, removing one metal as a powder by means of a current of air, and separating the magnetite from the unpowdered metals.

950,392. *Substitute for Celluloid*. Hermann Heydenbauss, Vienna, Austria-Hungary. February 22, 1910.

The composition comprises an animal albumin, carrageen moss, acetic acid, alcohol and formaldehyde.

950,436. Process for the Separation of *Oxygen and Nitrogen from Liquid Air*. Georges Claude, Paris, France, February 22, 1910.

950,455. Process of Making *Fertilizer*. Richard A. McVitty, Mullan, Idaho. February 22, 1910.

This is a process of preparing a fertilizer from sea-weed in its crude state, which consists in fermenting the sea-weed while confined until decomposition thereof is effected and a liquid mass produced, then removing the moisture from the liquid mass by evaporation and finally reducing the resultant mass to powdered form.

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THE CHEMICAL UTILIZATION OF MUNICIPAL WASTE.

By E. K. HAMMOND.

The development of a municipality has in all ages been marked by the appearance of certain problems, which are indicative of the degree of refinement attained in the city under consideration. Three of these problems may be regarded as typical and mentioned in the order of their importance they are:

1st—The provision and maintenance of a sanitary water supply.

2nd—The construction of a sanitary sewer system.

3rd—The satisfactory disposal of municipal waste.

The first and second of these difficulties have fallen to the lot of the civil engineer for solution while the third, after receiving considerable attention from various sources, has at the present time reverted to the somewhat modern profession of Chemical Engineering and it is the purpose of this paper to discuss in detail the method of procedure which is apparently the most satisfactory one yet devised.

The attention of the writer was first called to this question through his acquaintance with Mr. Charles Turner, President of "The Chicago Reduction Company," the firm which has charge of the disposal of refuse for the city of Chicago. The choice of this subject was further recommended by the courtesy of Mr. Turner, who gave permission to study the methods in vogue at the Chicago plant and furnished samples of the products, from the different stages of the process, for chemical examination in the laboratory.

Municipal waste may be divided into two general subdivisions, (1) household waste, and (2) street waste, while each of these general subdivisions may be further classified as shown in Table I.

A brief consideration of Table I will be sufficient to show the variety of the material which has to be dealt with under the heading of Municipal Waste, and this diversity in the nature of the material has been one of the chief obstacles in devising a satisfactory method of disposal. To obviate this difficulty a system known as "primary separation" has been put into effect by the ordinances of cities, such as Chicago, New York and Cleveland, Ohio, where the best systems of disposal are used. This system requires the separation of household waste into the three components shown in Table I, namely: Ashes, garbage and rubbish, by the householder, and that these three components be placed in separate receptacles ready for removal by wagons making periodical rounds for this purpose. In this way the question of disposal is far less complicated, since the material to be treated is somewhat homogeneous, and the results obtained have shown a most gratifying improvement.

The collection of garbage has been still further improved by the use of specially designed wagons, the body of which consists of a closed box made of sheet steel, the purpose being to reduce any odor nuisance to a minimum.

The methods of waste disposal which were, and are, in use previous to the development of the "Reduction

TABLE I.

Municipal Waste	Household Waste	Garbage.	Vegetable matter.
			Animal matter.
			Meat and bones.
			Fruits and vegetables.
		Ashes.	
		Rubbish.	Paper and rags.
			Leather and rubber.
			Wood.
			Bottles, crocks, cans, etc.
	Street Waste	Sweepings.	Sweepings.
			Manure.
			Droppings from carts
			Building material.
		Dead Animals	

Process" may be divided into two general groups. Those of the first group are applicable to all the classes of waste mentioned in Table I, while those of the second group are special methods of disposal devised for application to specific types of waste. There are six methods of disposal which are sufficiently important to demand mention and these appear in the following list accompanied by the class of material to which each method is applicable.

GROUP I.

Methods applicable to all classes of waste:

1. Dumping on land.
2. Dumping in water.
3. Incineration.

GROUP II.

Methods applicable to special classes of waste:

4. Feeding to swine. This method has been carried out with the better grades of garbage.

5. Ploughing into soil. This method has been applied to garbage and street sweepings.

6. "Reduction." Applicable to garbage.

Methods one and two have very little to recommend them and unless the dump where method one is applied is far removed from human habitation or the water where method two is applied has fixed conditions of tide or current to carry away floating material, serious complications may result from a sanitary point of view.

Methods four and five are open to criticism from a financial standpoint as it is evident that they are only open to application at points far removed from a city and consequently the expense involved in hauling the material to the point of disposal would be excessive. Method six, which is undoubtedly the best of the group, will be described in detail later in this paper.

Method three, incineration, is undoubtely the second in point of general efficiency, being only exceeded by the more modern method of reduction and where the quantity of waste to be treated is relatively small this method finds favor where its powerful rival, reduction, is excluded owing to the high first cost of the plant required to carry out the reduction process.

A typical form of incineration was that devised by Mr. A. M. Brainerd to dispose of the refuse of Chicago. This furnace was constructed at Superior St. and the river in 1891 and may be briefly described as follows: The wagons conveying the refuse to the incinerator were driven up onto a platform where the load was dumped opposite the entrance to three chutes. The material was transferred from the platform to these chutes by hand and passed down by gravity into the furnace.

The products of combustion from the furnace passed up the chutes and entered the main flue a short distance from the entrance. By this arrangement the moist constituents of the waste, such as garbage, were dried and the entire mass was partially consumed before reaching the bed of the furnace. This consisted of a cylindrical chamber about 8 ft. in diameter and 12 ft. in height. A working door was provided just above the grate bars of the furnace in order to provide means for stoking, which was a very important factor in the successful working of the incinerator. The combustion was facilitated by means of oil, which was sprayed in by means of a steam jet and by a forced draft furnished from a circular pipe surrounding the base of the kiln.

No attempt was made at this time to utilize the heat produced for the generation of steam, although this might readily have been done by means of either the fire tube or the water tube type of boiler. Aside from this possible source of revenue the system had many points in its favor. It was capable of handling all types of waste with equal facility and the temperature maintained in the incinerator was so high that the combustion of all organic matter was complete before it issued from the stack, thus precluding the possibility of any objectionable odors causing a nuisance in the neighborhood of the incinerator. This last feature enabled the final disposal of the waste to be carried out by this method at a point quite close to the vicinity in which it had been collected, thus cutting down the expenditure for teaming to a minimum. The residue left in the incinerator was an ash which was always in demand for filling and could be disposed of without the expense of hauling away.

The only drawback to this method of disposal lay in the fact that the material which was being burned in large quantities every day contained a considerable percentage of valuable constituents. The other methods described were, of course, open to this same criticism and it was to save these valuable components of the waste matter that the chemical engineers of the country began to work along the line of the "Reduction Process," about the beginning of this century.

Even at the time of writing, however, with the knowledge we have of the saving involved by reduction, it cannot be too strongly emphasized that, unless the amount of waste to be treated is sufficient to warrant the construction of a large reduction unit, the incinerator is by far the most satisfactory method of treatment, especially when provision is made for the generation of power from the heat developed in the combustion chamber, as it has been found that small reduction units cannot be profitably operated.

We have seen from the six methods of disposal previously mentioned that some attempt was made to use garbage and street sweepings as a fertilizer, but this attempt was crude and the expense of hauling was excessive owing to the fact that the material, containing about 82 per cent of useless moisture and 3 per cent of valuable grease was hauled long distances in this form in order to utilize the fertilizing properties contained in the remaining 15 per cent of the material.

Before entering upon the discussion of the reduction process it will be well to consider the chemical composition of an average raw garbage as it comes to the reduction plant.

TABLE II.

	Per cent.
Moisture	82
Grease	3
Tankage	15
Total	100

The tankage contains materials possessing value as fertilizers in the amount shown below:

	Per cent.
Ammonia	3.76
Phosphoric acid	1.47
Potash	1.87

A study of Table II brings forth the following conclusions: The raw garbage contains a large amount

of water, which is useless and adds very seriously to the expense involved in hauling, and a relatively small percentage of grease and valuable fertilizing materials, which would, however, assume some appreciable figure if they were considered on the basis of a sample freed from moisture. These were the prime factors which led to the development of the "Reduction Process," for it was apparent that if the raw materials was deprived of the moisture it contained the residue could be handled with much greater facility and still contain its original value as a fertilizer, while the extraction of the grease would add a considerable source of revenue without detracting from the benefit derived from applying the resulting tankage to the soil.

Two general methods of treatment are in use for the reduction of garbage and street sweepings. By the first method the refuse is subjected to a drying process by passing it through rotary kilns, which are heated by the products of combustion from gas or coal furnaces, and the grease contained in the residue is then extracted with naphtha. The residue is sold to fertilizer plants as a filler for fertilizer. This method gives satisfactory results except that, during the drying process, the fumes which are liberated from the stack are most objectionable. The second method of procedure obviates this difficulty. The raw material, to be treated by this method, is charged into steel cylinders where it is treated for a period of eight hours with steam under a pressure of 50 lbs. per square inch. These cylindrical tanks are provided with vent pipes at the top which lead to a condenser and any foul smelling vapors which may be produced are condensed before being discharged into the sewer. During this treatment the walls of the cell which contain the fats present in the garbage are broken down and during the subsequent pressing treatment to which the material is subjected any fat present is squeezed out along with a considerable amount of water, from which it is easily recovered by skimming, after it has been allowed to cool sufficiently to solidify. The residue remaining in the press is known as "tankage" and, this is dried and sold for fertilizer filler as mentioned above under the naphtha method.

Considering the two methods of reduction from every point of view it appears that rendering by steam is the most satisfactory.

In the first place a properly operated plant, of correct design, may be conducted with the production of very little objectionable odor, and this method of reduction is further recommended by the fact that the danger of explosion of naphtha is avoided. Another item in favor of steam rendering is that the steam consumed might be generated from the heat produced by the combustion of rubbish in an approved type of incinerator.

After a careful consideration of the subject the writer decided to select this method of procedure, and the subsequent part of this paper will be devoted to the design of a plant to handle 250 tons of garbage, 125 tons rubbish and 375 tons of street sweepings per day, in a town where primary separation is enforced, so that the various materials come to the plant in separate conveyances.

The ground plan of the entire plant is shown in Fig. 1, and the operation of the various elements composing it may be described as follows:

DISPOSAL OF RUBBISH AND STREET SWEEPINGS.

The wagons bringing rubbish and street sweepings to the plant discharge their loads in the yard indicated in Fig. 1, and the material is then moved onto the conveyors by men using forks. This conveyor leads to the charging hopper over the incinerators and passes a platform on which four men are stationed to remove all saleable material, such as rubber, leather and the better grades of paper and rags, as it moves by them. This part of the work is usually done by the employes of a separate firm, which has contracted with the reduction company for the privilege of removing the desirable portions of the rubbish at a stipulated sum, based on the amount of material taken.

The price paid is about $1.50 per ton and the results of this system in New York have shown that an average of 40 per cent by weight or 60 per cent by volume of the total rubbish coming to the incinerator will be taken by the trimming contractor. The remaining rubbish and street sweepings pass on to the charging floor of the incinerator.

The average results obtained at the incinerators, which are giving the most satisfactory results at present, show that the consumption per square foot of grate surface per hour is about 60 lbs. of rubbish. Using this as a basis and bearing in mind that 40 per cent of the total rubbish is removed by the trimmers, we shall have the total grate area required to be equal

$$\text{to } \frac{(375 \div 60\% \times 125) \times 2{,}000}{60 \times 24} = 625 \text{ sq. ft.}$$

It will be shown later that 11 boilers are required. This gives the area of each grate to be $\frac{625}{16} = 39.1$ sq. ft. The dimensions of the grate are taken as 6 ft. wide x 7 ft. long. The working doors of these furnaces are large, owing to the bulky nature of the fuel and every fourth furnace is provided with a door 4 ft. x 6 ft., in which the regular door of 18 ins. x 24 ins. is mounted.

The ash resulting from the combustion is free from all putrescible matter and hence it is applicable for filling purposes in conjunction with the ash collections which have been gathered throughout the city. The heat generated by the incinerators is utilized by a battery of 100 hp. boilers of the return type.

It has been found that the heating value of the rubbish, which comes to the incinerators now in operation, shows certain seasonal changes and it is the purpose of Fig. 4 to show these changes graphically. The minimum evaporative value of 1.3 lb. steam per pound of rubbish burned will be sufficient to generate 1,170,000

lbs. steam, which is greater than the total required for the operation of the plant.

Taking 1.5 lbs. as the average evaporative power of 1 lb. of rubbish, it will be possible to generate (375 ÷ 60 per cent × 125) 2,000 × 1.5 = 1,350,000 lbs. of steam from the combustion of the sweeping and useless rubbish coming to the plant.

GARBAGE DISPOSAL.

The garbage wagons dump their loads in the yard indicated in Fig. 1, and the garbage is carried by four bucket conveyors to the level of the third floor of the "rendering house." The bucket conveyors dump their loads at this point, on to horizontal wing conveyors which run directly over the digesters. These conveyors have gates situated directly over the charging holes of the rendering tanks, which may be opened as desired to fill the successive tanks. These tanks are similar in design to the one shown in Fig. 3. They are charged to the level shown, which will make the volume of the garbage contained equal to $\frac{6^2}{4} \times 9 \div \frac{1/36^2}{4} \times 3 = 264$ cu. ft.

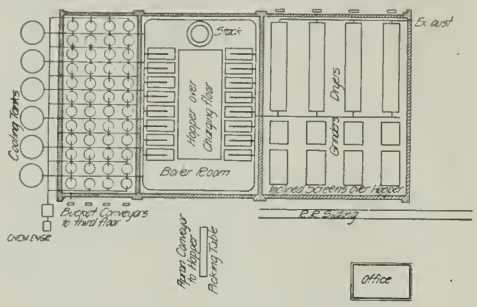


Fig. 1—Plan of Reduction Plant.

The garbage has an average heaviness of 40 lbs. per cubic foot. This will give the capacity of each rendering tank as 264 × 40 = 10,600 lbs. or 5.3 tons. It will thus be necessary to provide $\frac{250}{5.3} = 47.2$ or 48 as the total complement of rendering tanks. The 4 in. pipes entering at the bottom, the steam pressure being regulated by check valves so that it exceeds a maximum value of 50 lbs. per square inch. At the temperature so maintained, about 280.2° F., it will require eight hours to complete the rendering process. The reactions produced by this treatment are of a physical rather than a chemical nature, in so far as the recovery of the grease is concerned, and consists of the destruction of the cells which contain the grease so that the latter may be readily expressed during the next step in the process.

The crude garbage coming to a reduction plant will have a composition very similar to the result of an analysis made on a sample taken at the plant of the "Chicago Reduction Company," which is given below:

	Per Cent.
Moisture	68.55
Grease	3.76
Ammonia	1.72
Ash	26.03
Total	100.00

The ash was analyzed for phosphoric acid and potash and the percentage of these two constituents based on the original sample was:

	Per Cent.
Potash (K_2O)	.58
Phosphoric acid (P_2O_5)	.67

The rendering tanks are provided with ¼-in. vent pipes which carry away any objectionable odors, which may be produced during the rendering process, along with exhaust steam, to a set of jet condensers where the entire volume is liquefied before being discharged into the sewer. The condensers are of any standard type.

After the completion of the rendering process the steam is turned off and the material discharged from the rendering tanks into vats located on the first floor of the "rendering house." After allowing the "tankage" to cool for some time it is filtered through a standard type of filter press having plates 4 ft. by 5 ft. There will be twelve such presses required to handle the quantity of material treated during the day.

The liquor coming from the presses is run into cooling tanks where it is allowed to stand until the grease it contains has solidified at the surface when it may be removed by skimming and barreled for shipment.

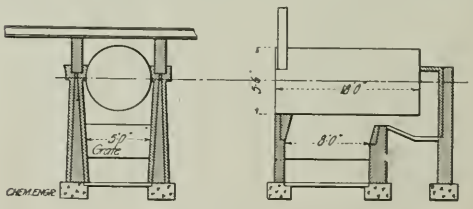


Fig. 2—Design of Grate for Incinerator.

A sample of the grease recovered at the plant of the "Chicago Reduction Company" by the naphtha extraction process showed the following:

Analysis:—	
Specific gravity	.899
Melting point (° C.)	27.2
Index of refraction (at 40° C.)	1.4576
Iodine number	48.53
Volatile fatty acids (per cent)	5.62
Insoluble fatty acids (per cent)	47.62
Soluble fatty acids (per cent)	36.24
Saponification number	175

The sludge left in the filter presses is taken by a bucket conveyor to the drying machines. These machines consist of horizontal cylinders surrounded by a steam jacket and connected with jet condensers. By this means the evaporation of the moisture retained in the tankage is accelerated, owing to the reduced pressure maintained by the condenser and at the same time any noxious vapors are condensed before being

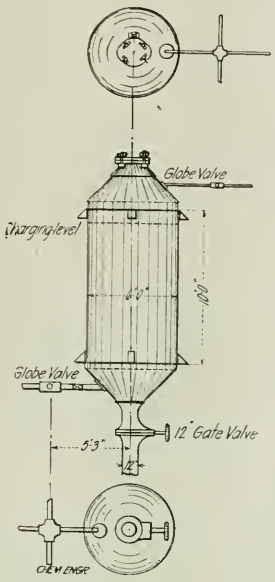


Fig. 3—Design of Rendering Tank.

discharged into the sewer. A shaft passes through the drying cylinder which carries a number of arms and when this shaft is caused to revolve by means of suitable belting the arms stir up the tankage and expose fresh surfaces to the drying action of the heat applied from the steam jacket.

The dried tankage is ground to a fine powder and is then removed to inclined screens through which it passes into hoppers, from which it is drawn to box cars for shipment. The final product is a dark brown in color and has an odor somewhat similar to roasted coffee. As it has been deprived of all purescible matter it cannot be objected to from a sanitary standpoint.

The analysis of a sample of tankage taken at the plant of the "Chicago Reduction Company" is given below:

	Per Cent.
Moisture	8.20
Grease	2.10
Ammonia	3.88
Potash	1.59
Phosphoric acid	1.78
Ash	28.27

The following list shows the various steam consuming elements of the plant:

1. Radiation losses from boilers.
2. Radiation losses from rendering tanks.
3. Discharge from rendering tanks.
4. Discharge from dryer.
5. Steam used for power.

Assuming that the loss of heat due to radiation, from an unprotected boiler surface is 2.8 B. T. U. per hour per sq. ft. of exposed surface, per degree F. difference of temperature between the boiler and the surrounding atmosphere, we shall have a loss from sixteen boilers 5 ft. 6 in. in diameter by 18 ft. long, equal to

$$16\times2.8\ (18\times3.14\times5.5+2\times3.14\times\frac{5.5^2}{4})\times(358^\circ-75^\circ)$$

$75^\circ) = 16 \times 2.8\ (358.6 \times 283 = 109{,}000{,}000$ B. T. U. Since it requires 1,108 B. T. U. to convert one lb. of water at 212° F. into one lb. of steam at 100-lb. pressure we shall have the loss due to radiation equal to the loss of $\frac{109{,}000{,}000}{1{,}108} = 98{,}500$ lbs. of steam.

The loss from 50 rendering tanks 6 ft. diameter by 16 ft. high at a temperature of 280.8° F. or 50 lbs.

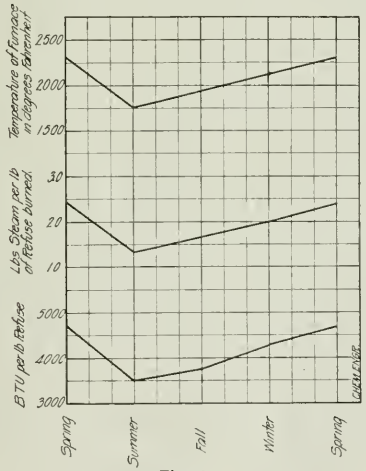


Fig. 4.

per sq. in. pressure is $50 \times 2.8\ (6 \times 10 = 2 \times \frac{1}{2} \times 6 \times 4.24) \times 8 \times (280.8 - 70) = 50 \times 2.8 \times 268 \times 210.8 = 1{,}000{,}000$ B. T. U. This is equivalent to the loss of $\frac{61{,}000{,}000}{1032.8} = 59{,}000$ lbs. of steam during rendering period of eight hours.

The total steam passed through the rendering tanks during an eight hour day is:

$$50\ F\sqrt{29\ h} = 50\pi \times \frac{.25}{144 \times 4}\sqrt{2\,g\,\frac{50 \times 144}{.036}}$$

550 cu. ft. per second = 57,500 lbs. of steam.

Allowing 1½ tons of steam per ton of tankage dried we shall have:

1.5 × 2,000 × 80 × 250 = 300,000 lbs. steam used in the drier if the crude garbage lost 20 per cent of its weight in the drying and pressing operations, which is about the condition which might be expected.

The power used to drive the conveyors and the agitator of the drying machines will aggregate about 21,600 lbs. of steam. Arranged in tabular form the consumption of steam appears below.

Total steam available from the combustion of rubbish is 1,350,000 lbs. The steam consumption of the plant appears below.

		Lbs.
1.	Radiation loss from boilers	98,500
2.	Radiation loss from rendering tanks	59,000
3.	Discharge from rendering tanks	512,500
4.	Discharge from dryer	300,000
5.	Power	21,600
	Total	1,051,600

This gives a surplus of 298,400 lbs. of steam which might be used for creating forced draft for the incinerators were such a procedure found to be advisable, or it might be used for the generation of power.

VALUE OF THE RECOVERED PRODUCTS.

The sources of profit from the operation of the rendering plant just described will consist of the recovered grease, the tankage and the saleable components of the rubbish.

The grease is listed under the heading of "Brown Grease" and has a value of from 3 to 4½ cts. per lb. with an average of 4 cts. per lb. This will give a yearly revenue of 365 × 250 × .03 × 2,000 × 4 = $219,000. The value of the tankage varies according to its freedom from grease and is based upon its components of ammonia, phosphoric acid and potash. It will have an average value of $3.75 per ton. This will give the value of the tankage recovered as 365 × 250 × .15 × 3.75 = $51,500.

Taking $1.50 per ton as the probable price available on a "trimming contract" for the portions of the waste removed there would be a profit of, 365 × 40% × 125 × $1.50 = $27,400.

This will give the probable yearly income as follows:

5,470,000 lbs. brown grease at $0.04 per lb.	$219,000
13,700 tons tankage at $3.75 per ton	51,500
18,250 tons saleable rubbish at $1.50 per ton.	27,400
Total	$297,900

It would appear from the figures quoted above that the reduction method of disposal is a most desirable method of procedure. It is to be feared, however, that the writer has inadvertently taken the position of demonstrating the qualities of the method described and in so doing has stated conditions in too favorable a light. This is possibly the case in the conditions selected for steam generation as there seems to be considerable diversity of opinion regarding the adaptability of refuse for fuel purposes. The results obtained in New York, however, would tend to support the assumptions previously made regarding the calorific power of the combustible portions of the waste.

The value of the recovered products is so considerable, however, that a very wide margin could be allowed for fuel, to be used for steam purposes, and still leave a profit to warrant the adoption of this method in preference to any of those previously described.

POTASH SALTS SUPPLIES.*

The new organization of the German Kali-Syndikat has been formally incorporated. It is stipulated that the companies holding American contracts can come in provided they terminate those contracts at the end of a year. If they decline to do so, a new syndicate will be formed.

The London correspondent of the American Fertilizer writes: "Until lately it has been believed that Germany was the only country in the world in which deposits of potassium salts existed. Now, however, the news of the discovery of potassium deposits in other countries is announced in the German press. According to the Brunswick Landes-Zeitung, the latest German discoveries are in Alsace, close to the French boundary, and the potassium deposits there will probably extend across into France, as has been the case with the salt deposits. It has also been established that deposits occur in Hungary, Russia, Holland and Persia. It is further announced that potassium salts have been found in China. Although the fact has been known for some time, it has been kept a secret, and the whereabouts of the deposits has not been disclosed. Samples of these Chinese salts have been tested by a chemist connected with the Potassium Syndicate, and the results have shown a large percentage of chloride of potassium.

According to a report of Consul John H. Grout, of Odessa, the 15 principal lake salt industries of Russia, mostly owned by the Government, and rented out on usufruct for very small considerations, have fallen into the hands of one family, the members of which have established a central office in Eupatria, the chief salt center, and have raised the price of the product from 2½ cents to 14 cents per pood (36 pounds), 8½ cents of which is profit. In consequence of this increase, suit has been instituted in the courts of Odessa against the combine, in which it is recited that ground salt in Odessa has risen from 7½ cents to 15 cents per pood, and other salt from 4 to 12 cents per pood. The total yearly production of salt in Russia is estimated at about 2,160,000 tons.

The lead pencil manufacturers of Nuremberg use about 700,000 tons of American cedar annually.

*Engineering and Mining Journal.

CHEMISTRY AND THE CONSERVATION OF OUR WATER RESOURCES.*

By PROFESSOR MARSTON TAYLOR BOGERT.†

The *quality*, as well as the quantity, of our water supply is a matter of grave concern. The purity of our drinking water is of vital interest to all of us, and it is to the chemist and bacteriologist that we must turn for assurances on this point. The character of the water used is also of very great moment in many industries.

The chief industrial use of water is for the production of steam; but if the water employed is rich in mineral salts, the formation of scale will proceed very rapidly. Hence, even in such a fundamental engineering operation as steam-power generation, the engineer must first consult the chemist as to the quality of the fuel and water to be used. In the United States, the average thickness of locomotive boiler scale is a sixteenth of an inch. This means a loss of at least 13 per cent in fuel efficiency. For an eighth-inch scale, this amounts to 25 per cent, and for a half-inch scale, to 60 per cent. Taking one-sixteenth inch then as the average boiler scale, this means for our 51,000 locomotives a total annual loss which may be conservatively estimated at fifteen million tons of coal. The use of pure water in the boilers reduces coal consumption, and by decreasing the amount of repairs and prolonging the life of the boiler reduces also the demand for iron.

In those operations where pure water is indispensable, the cost of impure water is the cost of purification, and it is to the chemist that the manufacturer must turn for instructions as to how this purification may best be accomplished. For some uses, as for boiler supply and paper making, the percentage of mineral matter is the chief concern; whereas, in such industries as brewing, distilling and ice manufacture, freedom from various micro-organisms must also be considered. Impure water means additional cost of production also to bleacheries, dye works, canning and pickle factories, creameries, abattoirs and packing houses, nitro-glycerin factories, woolen and strawboard mills, tanneries, chemical works, and factories for the manufacture of starch, sugar, glue and soap.

A serious problem arising in this connection is the steadily increasing pollution of our streams and tidewaters by sewage, factory waste, and refuse of all kinds. Practically all of our city and town sewage is disposed of in this way, together, often, with such other refuse as ashes, cinders, garbage and trash of every variety. In drainage and sewage there is considerable loss of valuable fertilizing materials, the annual loss in phosphorus alone being estimated as equivalent to 1,200,000 tons of phosphate rock. Few people have any idea of the vast amount of solid waste which must be regularly removed and disposed of in our great cities. In New York, excluding sewage, snow, street sweepings and dead animals, the solid refuse (mainly ashes, garbage and rubbish) amounts to over three million tons annually, or about 1,450 pounds for every man, woman and child in that city. This huge amount if piled together would occupy over eight million cubic yards. The removal of that volume of earth, for example, would suffice to excavate a canal twenty-seven feet wide, ten feet deep and one hundred and fifty miles long; yet that volume of solid refuse must be handled every year by the New York Street Cleaning Department, in addition to the items excluded above.

Sawmills, pulp mills, wood-distilling plants, tanneries, starch factories, cheese factories, sugar refineries, gas works, chemical works, glass works, dye works, oil refineries, distilleries and breweries, smelters, mining plants, and many other industries, pollute the streams with their wastes until the once crystal-clear brook becomes a mixture of water, particles of wood, earth, dust, cinders, fat, oil, soap, coal, wool, hair, and refuse of all kinds, and different chemical ingredients and colors—a blue-black, sluggish fluid. The waste of sulphite pulp alone in the United States is estimated at over one million tons a year, practically all of which finds its way into the streams, although it contains substances related to the sugars and the tannins which might be recovered with advantage.

Here is a most promising field for the chemist, and one in which he has already accomplished much. The manufacturer turns his waste into the stream for the same reason that the smelter allows his furnaces gases to escape into the air—because he thinks that it is the cheapest thing to do. If the chemist can show him how he can make more money by saving these by-products and using them either for the production of heat and power or for the preparation of valuable commercial substances, he will no longer dump them into the stream.

The Water Supply Branch of the United States Geological Survey analyzes the river waters to ascertain their potability, their suitableness for manufacturing operations or irrigation, or in relation to soil erosion. Recently, in co-operation with the Rhode Island State Board of Health, it has been making an investigation of various factory wastes now polluting the streams, and it has been found not only that all those so far studied can be satisfactorily purified at a reasonable expense, but also that in many cases it can be accomplished with substantial profit.

The poisoning of our streams and coastal waters also affects that portion of our food supply derived from these sources, by either killing off all fish and mollusca, or rendering them unfit for food. Brooks in the coal mining regions, once well stocked with fish, have become blackened mine drains, in which life of any kind is impossible. Although we are annually planting probably six billion fry in our inland and

*Address delivered before the Franklin Institute and printed in the Journal of the Institute.

†Columbia University, New York City.

coastal waters, an amount greater than all the rest of the world put together, those best qualified to judge state that the maintenance of fish life in this country is fast becoming impossible. Hence, if the chemist can bring about a reduction of this pollution, he will be assisting directly in preventing the loss of this food supply, to say nothing of the debt of gratitude which all the disciples of Izaak Walton will owe him. It should not be forgotten further that fish supply us also with oil and fertilizer material, as well as with substitutes for isinglass, gelatin and glue.

Although approximately two-thirds of the surface of our globe is covered with water, less than 5 per cent of our food supply is drawn from the sea. As it seems not unlikely that by 1950 the population of the United States will be at least two hundred million, the possibility of the seas contributing more largely to our support is worth considering.

Professor Bonnycastle Dale predicts that seaweed will some day be largely used for human food. Seaweeds have, to be sure, been used as food for ages, and in certain parts of the Orient constitute staple articles of diet, but the actual amount so used is at present relatively small. It has been calculated that enough proteids are lost annually in the decay of seaweeds on the sea beaches of the United States to take the place of the total product of our northwestern wheat fields. In the great Sargasso Sea sufficient nutritious vegetation flourishes and decays to support the entire population of Europe, if harvested and prepared in a form suitable for human consumption.

Thirty per cent of our horsepower now used is used electrically. At the present rate, it will equal or exceed power mechanically applied by the year 1920. As has been said before, we are entering the age of electricity, which means the age of water-power and the age of electrochemistry. The electrification of our railroads will result in the disappearance of one of the most frequent sources of forest fires—hot cinders from locomotive stacks.

Chemistry's services in the field of irrigation include the furnishing of the necessary explosives for rock blasting, cement and concrete for the dams, the analysis of the water, and the determination of the kind of fertilizers needed on lands reclaimed. The Bureau of Soils of the Department of Agriculture has been investigating the availibilty of mine runnings, and various waste waters, for irrigation.

The United States Civil Service Commission held an examination on April 20, 1910, to secure eligibles from which to make certification to fill a vacancy in the position of engineer in wood preservation. District No. 2, Forest Service, at $1,300 per annum, and vacancies requiring similar qualifications as they may occur.

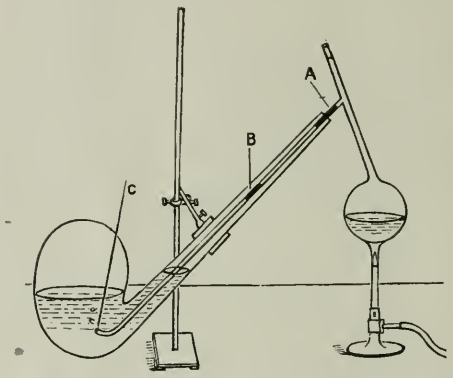
MODIFIED CHLORINE ABSORPTION APPARATUS.*

By R. H. McCREA.

In the course of some analyses requiring the distillation of chlorine into potassium iodide solution, the following modification of what I believe is Bunsen's apparatus occurred to the writer:

The iodide solution is placed in an inverted retort as usual, but a small distilling flask, say, 2 ozs., is used to distil from.

Into this is introduced the chlorate, chromate, etc., which can readily be done in the dry state, if desired, previous to adding the hydrochloric acid, by wiping dry the inside of the neck of the flask with a filter-paper beforehand. A suitable length of glass tube is connected to the side-tube of the flask at B by a piece of indiarubber connection tubing. The end of this tube at C may be conveniently bent slightly upwards.



Sketch of Modified Chlorine Absorption Apparatus.

A piece of rubber tubing is previously slid along the side-tube of the distilling flask to A, and by doubling this back upon itself it will be found generally to be thick enough to close loosely the mouth of the retort. When the retort is clamped as in the figure the whole arrangement is stable, and the rubber contrivance at A will be found to hold the distilling flask without any further support. At the end of the distillation this rubber tubing will be found very convenient to hold while removing the hot flask to prevent a back-rush.

It is important to gauge carefully the amount of solution placed in the retort, so as to prevent an overflow after the distillation has been commenced. Of course the usual precaution is taken of boiling the rubber stopper of the flask and the rubber connection at B in caustic soda solution to remove sulphur.

The above arrangement has the advantage of compactness, is very readily fitted together, and satisfactory results have been obtained from it in actual practice.

Chemical News, Feb. 18, 1910.

THE PLANT.

THE MANUFACTURE OF AIR-SALTPETRE ACCORDING TO THE PROCESS OF THE BADISCHE ANILIN AND SODA-FABRIK.*

By DR. SCHŒNHERR.

Nitrogen is peculiar among the commoner elements in that at ordinary temperature it shows little inclination to enter into combination with other substances. Practically all the nitrogen in existence, therefore, is to be found stored up in the free state in the surrounding atmosphere, while its companion there, oxygen, is met with all over the earth in hundreds of combinations, as a component of nearly every rock and as the chief component of water. Combined nitrogen, on the contrary, is found in but few spots on the globe.

Does it not then appear wonderful, that an element so slightly inclined to form compounds with other bodies should play so important a part in the organic world? Wherever there is life we find complicated substances containing nitrogen as carriers of this life. The protoplasm of the plants, the albumen of the animal world, that is, just the substances in which the actual processes of life take place, are compounds of nitrogen. It would seem, therefore, that organisms must have the power of taking atmospheric nitrogen up directly and turning it into organic bodies. As a matter of fact this is only to quite a slight extent the case; only low forms of life, certain kinds of bacteria, can so change atmospheric nitrogen that it can be assimilated by the roots of the higher plants. In this way, it is true, a continuous stream of atmospheric nitrogen flows, as it were, into the plants and from the plants to the animal world, but in spite of all attempts no one has yet succeeded in increasing this stream at will. On the contrary, if we wish to carry on intensive culture, particularly of our grain crops, we must make use of manures containing nitrogen. It is evident that stable manure cannot increase the nitrogen reserve of the organic world, for its nitrogen content is due to decomposed organisms, but also when employing the inorganic nitrogen manures, such as ammonium sulphate and Chili saltpeter, we are using up a supply which the organic life of earlier epochs has stored up for us. For ammonia is a product of coal; it is gained as a by-product in the distillation of coal, that is, from coke-oven sand gas-retorts. Much of the precious substance is still lost, but even if all were recovered its quantity can not be increased at will for the very reason that it is only secured as a by-product in another industry.

The second, much more important nitrogen manure, Chili saltpeter, is found in the rainless plateaus of Chili in enormous beds, probably due to the decomposition of sea-plants. Its occurrence in Chili is unique; in several other places on the earth small beds of nitrates are found, it is true, but none of them have the importance of those in Chili, where the annual export amounts to about 2,000,000 tons. For the chemical industry also saltpeter is an important raw material, being used for instance in the production of all explosives. But by far the greater quantity, about four-fifths, is consumed by agriculture, which must in future give to the soil even more combined nitrogen if it is to produce grain sufficient for the ever-increasing population and avert famine. At no very distant period the Chilian beds will be exhausted and it can thus be seen that it is of extreme importance to be able to combine the nitrogen of the air artificially in order to give the roots of the plants as large quantities as desirable. This problem can today be considered as solved, for the combination of atmospheric nitrogen is already carried out on a large scale by two processes. The first process, in the development of which Frank and Caro have gained great credit, produces the so-called "nitrolim," the active constituent of which is calcium cyanamide. If finely ground calcium carbide is heated in an atmsophere of nitrogen it changes into calcium cyanamide, taking up nitrogen and giving off carbon. By heating this cyanamide with water under pressure, the nitrogen is split off as ammonia. The same splitting off seems to take place in the earth, so that the lime-nitrogen can be compared in its effect as a manure with ammonium sulphate, but special precautions must be taken in its use. It cannot be employed for the many varied purposes to which Chili saltpeter is applied.

The second process gives a product which is in every respect the equal of Chili saltpeter, in certain soils indeed is even superior to it; namely "air-saltpeter," which has been placed on the market for some years under the name of Norway saltpeter or Nitrate of lime. While the air in the preparation of nitrolim must be separated into its constituents, i. e., the nitrogen must be secured pure, in the manufacture of air-saltpeter the air can be used just as it is. The chemical reaction is extremely simple and the fundamental observations were made very early. Already towards the end of the 18th century, at the very beginning of

*Translation of the lecture held at the meeting of the Elektrotechnischer Verein at Berlin, Jan. 13, 1910.

our present-day chemistry, Priestley noticed that nitric acid is formed when electric sparks are passed through moist air. Cavendish confirmed this observation, but at this early date no practical application could be made of it. In the course of his work on gas analysis in the middle of the last century, Bunsen noticed that nitric acid is also formed when oxy-hydrogen gas is exploded. These two observations teach us, therefore, that under certain conditions nitric acid is formed on heating atmospheric air. But, it will be said, we heat the air with every ordinary coal fire, with every gas flame, and notice no formation of nitric acid. There must thus be another condition present besides merely heating, which is not present in ordinary burning. This cannot be merely the high temperature, for we do not find any formation of nitric acid when using the oxy-hydrogen flame, which was early employed in industry and for lighting purposes; I will only mention Drummond's lime-light and soldering by means of hydrogen. In these operations nitrous gases are certainly formed, but in such extremely small quantity that they are not ordinarily noticed. The second point which must of necessity be observed if nitric acid is to be obtained in any quantity is a sudden cooling of the heated air. Thanks to the brilliant work of a whole number of scientists we can now follow by calculation the progress of the reaction which takes place on heating air and accurately define its conditions. Though I have spoken above of the formation of nitric acid, I must now express myself more precisely, for these labors have proved that nitric oxide is always the first product to be formed. Nitric oxide is a colorless gas composed of equal volumes of nitrogen and oxygen. If a mixture of oxygen and nitrogen is heated to a sufficiently high temperature, some of this body is always formed accompanied by the consumption of heat. In the formation of 30 grams of nitric oxide, 21,600 calories are consumed. According to a general law, more is formed the higher the temperature is raised, but for each temperature there is a definite percentage above which the formation cannot be increased, however long the heating is continued. The bodies are then said to be in equilibrium. We must not think of this equilibrium as a stable condition as met with in mechanics. There, bodies in a state of equilibrium remain at rest relatively to one another; here, on the contrary, we must consider that in this state also the various bodies present react energetically on one another, but nothing of this can be directly noticed for the relative proportions of the bodies present do not change, because in a unit of time just as much nitric oxide decomposes again to its constituents as is formed in the same space of time. According to Nernst there can be formed in atmospheric air at an absolute temperature of:

1500° C.	0.1% nitric oxide.
1928° C.	0.5% nitric oxide.
2202° C.	1 % nitric oxide.
2403° C.	1.5% nitric oxide.
2571° C.	2 % nitric oxide.
2854° C.	3 % nitric oxide.
3103° C.	4 % nitric oxide.
3327° C.	5 % nitric oxide.

We can see from this table that at an absolute temperature of 1500° C. only 0.1% of nitric oxide can be formed. On raising the temperature by 428° C. only 0.4% more is obtained, i. e. 0.5%, while on raising the temperature about half as much from 3103° to 3327° C. the quantity of nitric oxide rises by 1%, that is about four times as much as for a similar interval at the lower temperature. In any case however, it is evident that quite small quantities of nitric oxide are formed, so that a considerable useless ballast in the form of air has to be heated too.

When we calculate what quantities of heat must be used to produce at 1928° C. and at 3327° C. the same weight of nitric oxide, we find that they stand in about the proportion of 5:1, that is, we require five times as much heat to produce the same quantity of nitric oxide at 1928° as at 3327°.

From this it can be seen at once that those processes have most chance of technical success in which the air is heated to a very high temperature. With the aid of the electric arc a temperature of 3000° C. can be attained, so that it ought to be possible to produce concentrations of 5% nitric oxide. This is unfortunately not the case. On raising the temperature not only does the absolute concentration attainable increase, but also the velocity at which the reaction proceeds: this reaction velocity, however, represents both the rate of composition and that of decomposition of the body, for in the same unit of time just as much of the body in equilibrium disappears as is produced. Thus the rate of decomposition also increases with the temperature, at 3000° C. it is about 10,000,000 times as great as at 1900° C., so that the cooling down must be effected with enormous rapidity. Strictly speaking the particles of air should pass through the interval of temperature from 3000° C. down to about 1500° C. in an infinitely small time, in order to preserve their original content of nitric oxide. This is of course impossible, so that the yield of any process chiefly depends on the more or less skilful manner of carrying out the cooling. Cooling by means of the excess of air carried along has always proved itself to be the most effective means, and this method is used, knowingly or unknowingly, in most of the processes applied technically. All other means of cooling work too slowly. The use of air as cooling agent is also favorable to the preservation of the nitric oxide formed, in that it reduces the concentration of the latter, for the rate of decomposition falls very quickly with the dilution.

These theoretical explanations of the reactions which take place on heating air, which are based on the idea of a purely thermal action, have been proved by a series of exact experimental investigations, but the recent work of Haber and König have made it doubtful whether they apply to electrical heating. Al-

ready at the general meeting of the Bunsen Society at Dresden in 1906 Warburg drew attention to the fact that in his opinion effects other than purely thermic were brought about in treating air in an arc, and later Haber and König succeeded by the observation of certain conditions in producing nitric oxide of such high concentrations as could never be obtained as the result of a purely thermodynamical equilibrium. In their experiments they worked with air at a pressure of about 100 mm. mercury, and obtained concentrations of nitric oxide of 10%. I am unable to go into these interesting experiments, but I would point out that these special results, which were certainly obtained by Haber using diffuse discharges, are so diminished in technical working when very large quantities of current are used with an air pressure differing only slightly from the normal, that the purely thermal explanation of the process can be retained for treatment under these circumstances.

The high concentration is dependent not merely on the temperature, but also on the proportion in which the two reacting bodies stand to one another. The equilibrium constant is found according to the law of mass:

$$K = \frac{C^2_{no}}{C_{n_2} C_{o_2}}$$

The concentration of NO has, therefore, the highest value at each temperature when the product $C_{n_2} C_{o_2}$ is a maximum. It is directly proportional to the square root of this product. In air with 21 parts by volume of O_2 and 79 parts of N_2, this product is $0.21 \times 0.79 = 0.16$, while in a gas mixture of equal parts of oxygen and nitrogen it is $0.5 \times 0.5 = 0.25$. If this mixture is made use of instead of air, the concentration increases, and the yield accordingly, to

$$\sqrt{\frac{25}{16}} = \frac{5}{4}$$

i. e. by about 20 per cent. It might be thought that it would be profitable to make use of such mixtures rich in oxygen, but it is not yet done on the large scale. To produce such mixtures requires costly appliances and expenditure of energy, so that the higher concentration of nitric oxide would not represent profit. It would not be possible to let the air escape into the atmosphere after the last absorption, and lead fresh quantities to the burners, but a closed gas circuit would have to be provided and this involves many difficulties. At the same time I do not consider it improbable that in future such artificial mixtures will be worked with.

If the thermal explanation of the reaction is adopted, it is a matter of indifference of course in what way the nitrogen-oxygen mixture is heated, and consequently every imaginable method of heating for this purpose has been proposed as is shown by the patent literature of the last decade.

Oskar Bender (British Patent No. 8653/07) heats the air in a generator by means of coal to a temperature as much above 1000° C. as possible. In the upper part of the burner is a tube through which is led superheated and strongly compressed steam, which is supposed to dissociate in the heat of the burner. The oxy-hydrogen gas thus produced causes, on burning, a further rise of temperature in the air which has been previously strongly heated. This is of course impossible, for the heat produced by the burning of the oxy-hydrogen gas must first be taken from the heated air. In the same way the Westdeutsche Thomasphosphatwerke try to heat a mixture of air and steam so high, that an extensive dissociation of the steam takes place. Before the gas mixture cools down, the hydrogen produced is removed by diffusion through porous walls, in order to avoid on cooling a reduction of the nitric oxide formed (German Patent No. 182,297). The diffusion is assisted by difference in pressure. Guido Pauling has patented a somewhat similar arrangement in America (Patent No. 758,774). He heats the air by means of an oxy-hydrogen flame and removes the small quantity of free hydrogen present by the addition of chlorine. Karl Södermann (Norwegian application No. 23,201) aims at previously heating the air in a system of tubes to 2000° C. and then raising its temperature by means of an acetylene flame to from 2400—2600° C. It can at once be seen, I think, that heating by means of acetylene, which must be gained indirectly from the calcium carbide produced by electrical energy, has no advantages over the use of electrical heating. Brünler and Kettler have taken out patents (France Nos. 363,617, 363,618, 380,467) for flames burning into water. Pawlikowsky (British patent No. 26,728/05) proposes to produce the heat by compression, regaining the greater part of the energy expended by the following expansion. The heat used up in forming the nitric oxide he proposes to replace by flames from a second source of energy or electric discharges. Häusser (Verhandlungen des Vereins zur Beförderung des Gewerbefleisses, 1905, page 295) proposes to produce nitric oxide in a combustion compressor after the maximum temperature has been reached by means of compression and explosion, by spraying in a cooling agent and so cooling the gases that a decomposition of the nitric oxide is no longer to be feared. The residual heat still contained in the compressed gases can be used in the production of mechanical work. The energy which is lost by spraying at the maximum temperature is to be taken as the cost of work in producing the nitric oxide. When the cooling is carried out for merely a short but fairly high interval of temperature, quite good yields should be obtainable theoretically according to this process. A somewhat different manner of carrying out the same idea is contained in Häusser's later British Patent No. 13,980/07. Here also he compresses combustible gases with an excess of air, but then explodes the mixture heated in this way in a special chamber.

Patents in which the heating is carried out purely by electric discharges are the most numerous, and up to the present only this method of heating has proved useful in actual practice. The reasons for this can

readily be understood. On the one hand, by means of electric heating the highest temperatures at our command can be employed, which is very desirable for attaining high concentrations of nitric oxide; and on the other hand there is not the same possibility of carrying out the specially effective cooling by means of an excess of air with any other form of heating. With the other methods of heating, the concentration of nitric oxide is very low to begin with, and it is still further reduced owing to products of combustion becoming mixed with it. If then further quantities of air were added for cooling purposes the concentration of the nitric oxide would be so remarkably low that the difficulties of absorption, of which I shall have to speak later, would be enormously increased.

The first attempt to produce nitric acid by means of electric discharges taught that the yields were improved when arcs of a very small energy content were used. For a long time, therefore, it was held that discharges of a large current strength were to be avoided and the most complicated arrangements were devised in order to feed a large number of weak arcs from a single powerful source of energy. Every technical electrician can judge of the tremendous difficulties opposed to this way, and the exertions of a whole army of inventors were brought to nought by this problem of the division of energy. This is the reason why the first attempts to produce nitric acid on a large scale by means of electricity, which were carried out in America by the Atmospheric Products Company, were not successful. The efficiency of the apparatus stood in no relation to its expensiveness. At that time the apparatus was described in all the technical papers, for the undertaking was the first of its kind and aroused everywhere the greatest interest. It consisted of an iron cylinder of 1.5 m. in height and 1.25 m. in diameter. In the axis of this cylinder a steel shaft rotated which carried 23 zones of electrode arms, each zone containing 6 arms and each arm being provided with an electrode. Opposite to these electrodes in the wall of the cover were a like number of fixed electrodes. The ends of all the electrodes were composed of platinum wire. The various rows of electrode arms were opposed to one another, so that during rotation as continuous a current as possible might pass through. In this way 414,000 small arcs were formed and extinguished per minute. The strength of the current was only a few milliamperes per arc. Besides this, the apparatus was not fed with an alternating current, but with a direct current of 10,000 volts. The manufacture by the company, if the word manufacture can be used, for so far as I know only a single apparatus was worked, was stopped in 1904, as being hopeless.

A large number of patents have been taken out by other inventors also, in which weak arcs, or even spark discharges, have been used for the production of nitric acid. Many of these remained purely paper patents, others stuck in the experimental stage, so that I need not go into details on them. It was impossible for an industry on a large scale to develop on such a basis.

A sound basis for the industrial application of the combustion of nitrogen by means of the electric arc was only obtained when Birkeland and Eyde succeeded in obtaining good yields with arcs with very strong currents. Their invention dates from the year 1903. They used the property of the magnet to drive an electric arc to one side, just as it will any other moveable conductor. Their furnace consists of a low box-shaped space, lined with fire-brick into which copper electrodes cooled with water are introduced from the narrow sides. The furnace is arranged in the field of an electro-magnet so that the lines of force of the magnet run at right angles to the plane of the furnace. In consequence of this arrangement an arc struck between the electrodes by means of an alternating current is alternately blown out upwards and downwards, and makes the impression on the eye of a large disc of light.

In this simple manner the Norwegian inventors created an extraordinarily efficient apparatus for the combustion of nitrogen, which worked without any moving parts and permitted of the application in one furnace of about one hundred times as much energy as did the complicated apparatus of the Atmospheric Products Company. There is now at work at Notodden in Norway a factory utilizing 30,000 hp. according to this process, and the initial difficulties from which every new industry suffers are overcome.

Since towards the end of the 90's at the instance of Dr. von Brunck, the far-seeing and enterprising manager of the Badische Anilin- & Soda-Fabrik, experiments aiming at the artificial production of nitrate have been carried on in the factory at Ludwigshafen, utilizing the rich resources of the works there for the investigation. In the year 1905 I succeeded in discovering a method of burning nitrogen which requires an even simpler apparatus than the magnetic furnace. In working out this process I enjoyed the invaluable collaboration of my colleague, the engineer Mr. Hessberger. In previous processes it had been regarded as advantageous if the arc only burnt intermittently, or on the other hand if it burnt continuously then it was regarded as desirable that there should be very rapid vibrations through the air to be treated, and finally in the Birkeland-Eyde furnace there were a series of rapidly moving arcs combining the two previous ideas. Now as distinguished from these processes, the process of the Badische Anilin- & Soda-Fabrik makes use of an arc of great current density which burns quite steadily and is maintained in a stable condition.

Of course this arc is of an altogether peculiar nature. In my work on the problem of burning nitrogen, I soon learned that it was quite impossible to blow large quantities of air directly through an arc, although according to the description of very many patents this is attempted by others. In such attempts only a very small proportion of the air goes into the sphere of action of the electric discharge, and very dilute gases are obtained. On the contrary we obtain highly con-

centrated gases if the air is led along and in close contact with a quietly burning arc. This may sound much easier than it actually is. The freely burning arc of great length is an extraordinarily fragile thing; it goes out on the least provocation, even if the conditions are such that one must believe that every movement of the air from the side is impossible. But if it is desired to have good energy yields, it is essential that considerable quantities of air shall be brought into contact with the arc, so that the current of air must possess a very considerable velocity. This of course at once increases the danger of blowing out the arc. Further it is in the very nature of an arc produced by an alternating current, that it should be unstable, and as things stand now polyphase currents alone come into consideration. The change of phase in such a current itself, its increase from nothing to the maximum, its change in direction, constitute such violent disturbances to a regulated flow of air that it might be thought impossible to solve this problem in a satisfactory manner. It is much easier to keep an arc produced by a direct current burning. By the application of a simple expedient, however, all the difficulties of maintaining an arc obtained from an alternating current have been overcome. This is effected by driving the air along the arc not in straight lines, but giving it a whirling motion, so that as it passes along the arc, each particle moves in a path resembling the thread of a screw. Under these circumstances the arc burns as steadily as the flame of a candle, and it can be enclosed in a comparatively narrow metallic pipe without the arc striking over to the wall; if the air be directed along the arc in a straight line there is a tendency for the arc to strike into the wall earlier than is desired, and when working in this way it is not easy to use a metallic pipe, whilst the use of a non-conducting tube has its disadvantages. In our manufacture at the present time we use exclusively arc flames burning in the center of a whirling current of air in an iron tube. The apparatus itself is very simple. It is only necessary to arrange in a tube an electrode insulated from this, and to drive through the tube a current of air giving it at the same time a rotary motion, and then to start the arc in any suitable way. This can be effected most simply by making the distance between the insulated electrode and the wall of the tube at one place so small that on making contact an arc springs across. As soon as this has happened, the current of air drives one end of the short arc which is at first formed along the wall of the tube and the result is a long arc flame burning in the axis of the tube, the end of this arc striking the wall at a considerable distance from the insulated electrode. This point is determined by the temperature of the gases; at the place where the gases have acquired such a high temperature that they have sufficient conducting power for the arc to pass through them, this of course happens. As there must always be an inductive resistance in the arc circuit, when once the arc is started the electric tension sinks to such an extent that there is no occasion to fear the arc striking across again at the narrow part where the first ignition was effected. Should the arc go out for any reason, its re-ignition occurs automatically. This method of igniting the arc can be seen from the apparatus to the left in the accompanying sketch (Fig. 1). The tube which serves as the outer boundary of the whirling air current is in this case of glass. Within this can be seen a spiral of metal foil; it may be taken that this is a metallic tube-furnace, such as is used in manufacture, from which all the metal has been removed except this spiral. This must necessarily remain in order to permit of the arc climbing up the apparatus to the metallic head of the furnace. The end of this spiral at the bottom is only a short distance from the insulated electrode situated in the axis of the tube, so that at this

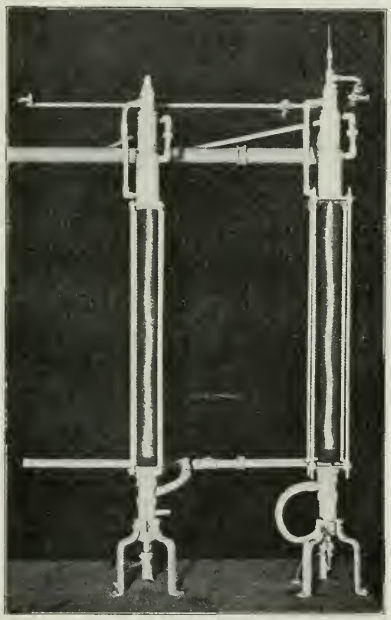


Fig. 1—Demonstration Tube.

point, when the tension in the circuit rises to 5,000 volts at first quite a small arc is formed. Later when the arc-flame is burning, the tension falls so much that no current passes over at this point and it can be seen that even higher up the arc does not touch the spiral, but only ends on the metallic head of the furnace. Of course all the conditions must be suitably chosen. The small arc shown in this apparatus utilizes about 7 kilowatts electric energy, that is to say in round figures 10 hp.

This method of igniting the arc is very suitable for demonstration purposes, but it is not used in our actual furnaces. We abandoned this very soon because in manufacture it can readily give rise to interruptions. In the other furnace to the right in Fig. 1 the spiral is omitted. In this case, in order to start the arc it is

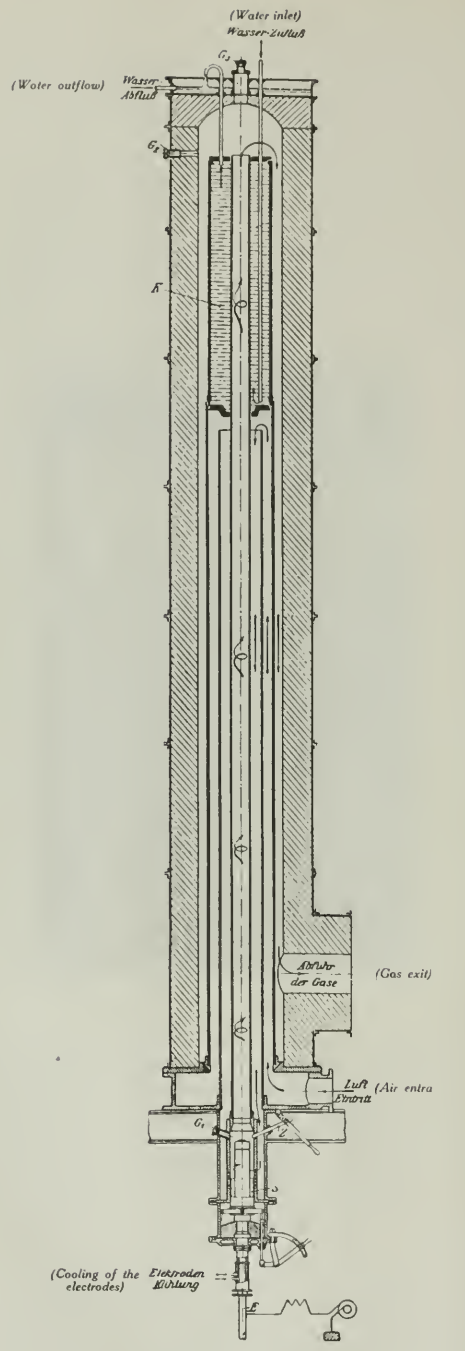


Fig. 2—Diagram of Furnace for the Production of Nitrogen From the Air.

necessary for a moment to bridge over the distance between the two electrodes with the aid of a wire, and it is a method similar to this which is adopted in manufacture. In Fig. 2 I show a diagrammatic drawing of a furnace as used in manufacture. You will see on this a lever by means of which a massive iron bar Z can be moved from the wall of the tube, which for the time being acts as the second electrode, to the insulated electrode E. As the entire casing of the furnace with the sole exception of the central electrode is put to earth, there is no danger for the operator when igniting the arc.

In an experimental manner we have tried every conceivable method of igniting the arc in our furnace. It can be effected by permitting a spark to cross from the electrode to the wall, or by blowing in a small flame from an opening in the outer wall against the central electrode, or a very fine wire having great resistance can be passed from the wall of the pipe to the insulated electrode. Immediately the current passes, this is burnt up and passes away as dust on account of the great density. A moist splinter of wood, or anything of that kind can be similarly used. As the electric tension amounts to 4,000 to 5,000 volts very slight conductivity is necessary in order to bring about the ignition of the arc. On account of its curiosity I will mention one more experiment that we have made. We have ignited the arc by firing a blank cartridge from a revolver at the inner electrode. These experiments were made in order to determine how far it may be possible to diminish the inevitable rush of electricity which occurs at the moment of ignition, but as our furnaces only exceptionally require reignition the method that is adopted is of small importance.

The rotary motion of the air can be obtained in the simplest manner by forcing the air into the tube in a tangential direction. If the air be blown into the tube through a single opening, its course will naturally assume the form of a screw with one thread and the course of the screw forces the arc flame somewhat to one side, giving this to a certain extent the screw form, which can readily be seen from the photograph of the arc in Figs. 1 and 3. In the newer apparatus, Fig. 4, the entrance of the air into the furnace is effected through a series of eight openings in the same plane at the bottom of the tube. All eight openings are bored tangentially in the wall of the tube, and the air passes into the tube in a very even current. In this furnace no deformation of the arc-flame occurs, it can be seen to be burning in a straight line. In the manufacturing furnaces the air passes in through several series of tangential openings the series being situated one above the other and over these a movable sleeve S can be moved. In this way it is possible, whilst using the same quantity of air, to lengthen or shorten the arc-flame. We can consequently feed the furnace with varying quantities of energy and still keep the length of the flame about the same and obtain gases of practically the same concentration of nitric oxide.

The equipment in Ludwigshafen only permitted the utilization of a single furnace fed with 300 kw. of energy. We therefore erected an experimental factory in Kristianssand in the south of Norway in order to test experimentally our furnace in continuous work, using larger energy units. This factory started working in the autumn of 1907. It worked well from the beginning, and our furnaces after working for more than a year have proved themselves to be fully successful. The energy is obtained from a power house in the Saeterst, 6 km. (16 miles) away, in the form of a 3-phase current. The transmission is effected with a tension of 25,000 volts with triangular connection. In the factory the current is transformed to one with 7,200

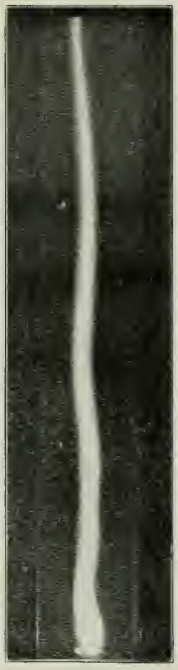


Fig. 3.—Arc 75 c. m. Long In a Glass Tube.

volts, so that the tension of each phase is 4,200 volts. The furnaces themselves are connected with star connections. We have available at the factory about 1,300 kw. in the form of this 3-phase current, so that we could feed the three furnaces with 600 hp. each. The figures 6 and 7 show views at this experimental factory. For short periods we have worked with furnaces utilizing 1,000 hp. and our future factories are to be fitted only with this larger type of furnace. We have even thought we can build with equal success furnaces utilizing 2,000 hp.

Fig. 2 shows the construction of our present furnaces. The electrode which is insulated from the rest of the furnace can there be seen in the axis. It consists of a strong copper body pierced through its axis and cooled with water. Through the axis passes an iron bar E, which can be pushed forward as required and constitutes the actual electrode from which the arc proceeds. All the wear comes upon this bar. Under the intense heat of the arc it becomes covered with a layer of melted ferric oxide, which slowly evaporates. As this evaporation proceeds the iron bar is pushed forward. This only occurs very slowly and the wear and tear of the electrodes is an altogether trifling matter. The costs under this head are only a few farthings per kilowatt and year. The bars of the length that we use for electrodes last for about 2,000 working hours, that is, for about a quarter of a year. To insert a new bar, it is simply screwed on to the old one, and this can be effected in about 15 minutes. The water-cooled copper body which surrounds the iron bar is kept at such a distance from the wall of the furnace tube that there is no occasion to fear current passing from it to the

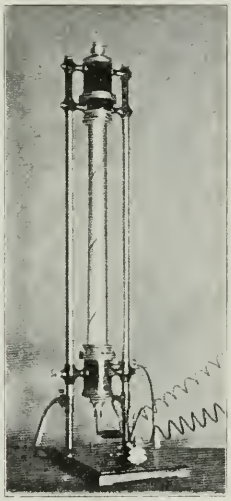


Fig. 4—Demonstration Apparatus of New Construction.

wall. The igniting rod Z, which has already been mentioned and which can be moved till it touches the electrode, is used for starting the arc. There is a peephole, G_1, near the bottom of the furnace through which the starting point of the arc can be seen, so that the adjustment of the electrode can be effected at the right time. We perform this adjustment by hand as required, but, if desired, it could easily be effected continuously by purely mechanical means. In the figure the sleeve S for regulating the air current, which has already been mentioned, can also be seen. In our Kristianssand furnaces, utilizing 600 hp., the arc is about 5 meters long; in the 1,000 hp. furnaces which were worked with a higher tension, arcs of 7 meters length were obtained. The tube enclosing the arc is simply an ordinary iron pipe. The arc only ends on this pipe for a moment when it is started, so that it wears practically for ever. The upper part of the tube

is constructed in the form of a special cooler, like a Liebig's condenser. The arc is made to end in this part of the apparatus by suitably manipulating the air-regulating valve. There are two peep-holes in the upper part of the furnace through which this can be checked. The opening at the top permits a view along the axis of the arc and looking down this way it can be readily seen that the upper end of the arc changes its place constantly, moving round in a circle, but the arc varies also slightly in length, so that the end of it comes into contact with a comparatively large surface of the cooler, and no part gets overheated. The wear of the cooler is consequently very slight. Apart from this it is so constructed that it can be readily repaired. It is only necessary to roll in a new tube. We removed the tube of one cooler after it had been in use for four months, and it was hardly possible to notice any wear at all. After the hot gases have passed through the cooler they pass down an annular space surrounding the inner portion of the furnace, and from this enter a flue common to all the furnaces, and through this flue they pass along to a boiler which acts as a cooler for the gases and in which steam is

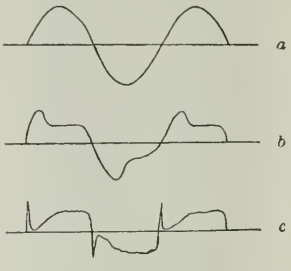


Fig. 5.

generated that is subsequently used for concentrating the solutions produced later on in the process. It will readily be seen that the gases on passing down the annular space in the furnace give up a portion of their heat to the tube through which the air supply passes to the furnace, as can be seen from the figure. This air enters the outer part of the furnace at the bottom, passes upwards, and then downwards, turning below the cooler, and in this way takes up heat from the gases passing away from the furnace. When the air enters the furnace it has in this way been subjected to a thoroughly preliminary heating. The entrance to the inner tube containing the arc flame is effected, as has already been mentioned, through the tangential openings.

It is not essential that the arc flame be vertical. We have also used furnaces with a horizontal flame, and this position can be shown by turning a demonstration furnace on its side. It can be seen that in this position also the flame burns quietly in the axis of the tube and the ignition can be effected in the same way as in a vertical furnace. Similarly, if desired, the air current can be passed in from the top to the bottom, and if the furnace be made short enough and the exit end of the furnace left open, an enormously hot blow-pipe flame possessing strong oxidizing properties can be blown out of it. An arrangement of this kind is specially suited for smelting operations, accompanied either by oxidizing or reducing effects, which are brought about by suitably choosing the gases employed. For such a purpose the melting crucible and its charge would act as the second electrode. Of course if desired several tubes can be used, for instance three tubes can be connected with the three phases of a 3-phase system, and the melting crucible and its charge would be connected with the neutral junction. Further, if desired, the arc flame may be made crooked; it may for instance be vertical in its lower part and horizontal in its upper part. This can readily be arranged with the aid of the whirling motion given to the air, in particular, after a bend in the furnace a further supply of air can be blown in through tangential openings. It is of course in no case necessary to blow in all the air at one part of the tube; on the contrary it can be effected at several places lying far from one another, and in this way it would be possible, if it were desired to do so, to produce arc flames of very much greater length. Again, the tube which encloses the arc flame need not be cylindrical, it may be entirely or partly conical. All these modifications are mentioned to show that almost any desired manipulation of the electric arc flame is possible; when using the whirling motion of the air as described the arc flame can be kept stable

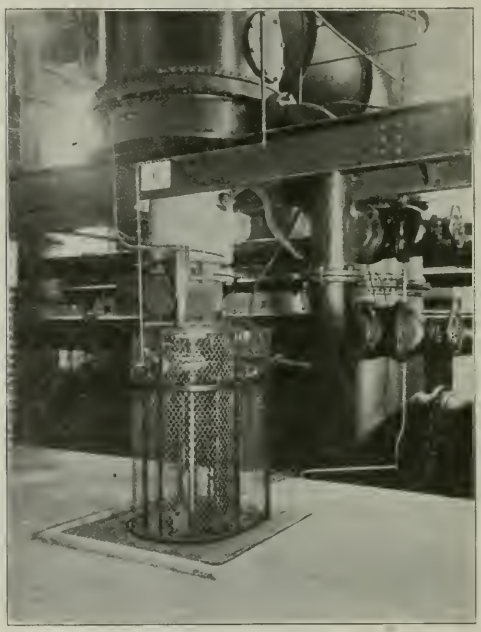


Fig. 6—View of Underpart of a Furnace.

in positions of all kinds to a degree that appears hardly possible. When our furnaces are properly set up, it seldom occurs that the arc flame requires igniting afresh. Interruptions only occur if for some reason or other there are sudden violent variations in the air supply, or again if a short circuit occurs in the supply line, or from any other reason the tension of the current drops essentially. The current and voltage curves can be seen to coincide nearly with the curves of sines in Fig. 5. Curve *a* is a chart of the voltage curve of our arc flame, curve *b* is the corresponding curve from an ordinary electric light lamp, and curve *c* is the curve of the Birkeland-Eyde arc. It is noticeable that the ignition peak in the tension curve which can be most clearly seen in the case of the other arcs, is entirely absent in ours, and that there is only a very slight unevenness in the rising and falling part of the curve. Agreeably with this the efficiency of our arc flame is

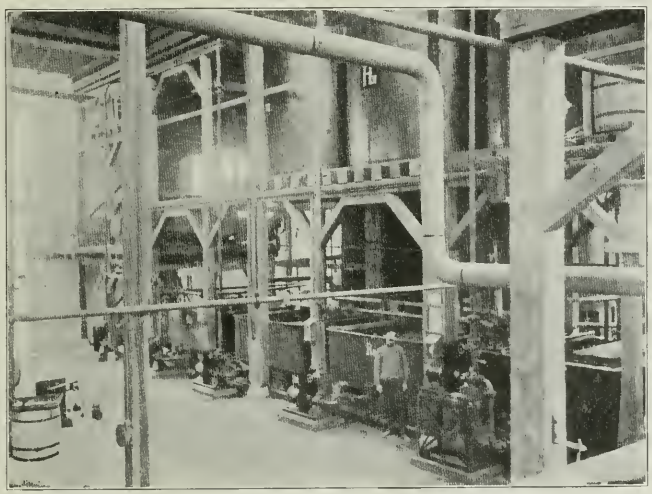


Fig. 7—View of Absorption Room of the Experimental Works Near Kristianssand.

very nearly 1; it amounts to from 92 to 96 per cent. This excellent result can probably be explained as follows. During several periods probably the current is conducted by practically the same air particles, consequently smaller variations in the resistance occur than is usually the case with electric arcs. Of course in every unit of time new air particles enter into the field of the current and others leave the arc flame at the other end, but the number entering and leaving the arc is small compared with those which at one time are in the arc flame. An objection has been urged to our arc flame by a critic, that the air remains too long in contact with it, but from the above it can be seen that this is not a disadvantage, but in this respect distinctly advantageous. The fact that the air is acted on for a comparatively long time in the arc flame has no injurious effect on the yield either, for with our arc flame there can be obtained essentially higher yields than

according to the process of Birkeland and Eyde. As the air particles which conduct the current do not mix with the rest of the air between the alternations of the current, no cooling of these particles takes place during these intervals, except by radiation, and this, as is well known, is very small for gases, so that it can readily be understood that the prolonged treatment of the air in the arc flame does not necessarily involve a loss of energy. Our tube furnace really corresponds in its action completely to the apparatus used by Nernst for the examination of the nitrogen-oxygen equilibrium. In this apparatus also the mixture of gases was heated for a long path, so that with certainty the equilibrium should be attained, then for a short portion of its path it was quickly and effectively cooled. In our furnace the cooler air which surrounds the arc flame like a mantle and which prevents the too early discharge of the arc to the enclosing iron tube, only becomes gradually warm. This air of course keeps at a temperature far below that of the arc flame itself, and at the point where the arc strikes through it, it serves in the most efficacious manner for cooling down the most highly heated air of the arc flame which is also that which is richest in nitric oxide. The whirling motion assists this cooling effect, in that it brings about a perfect and sudden mixing of the air and causes the flame to move so as continuously and regularly to change the position of its end point.

We have experimentally determined the fall of tension in the arc flame by the insertion of subsidiary electrodes, and have found that the fall in voltage proceeds fairly evenly along the whole length of the arc flame. Determinations of the concentration of the nitric oxide have also been made at different parts of the arc flame, and as was to be expected it was found that the concentration was highest in the axis

of the flame and towards the upper end of the arc. In the actual path of the arc flame itself, it is probable that the concentration is equally great all along, but owing to the higher velocity of decomposition and the temperature of the arc flame it is unfortunately impossible to determine this concentration by taking a test sample directly.

Turning now to the question of the utilization of the energy, it must be confessed that if only that portion of the energy be taken into consideration which is used for the formation of nitric oxide, this proportion is very slight, since only about 3% of the total energy that is fed to the arc flame is utilized for the production of nitric oxide; but this method of calculation is not accurate, for besides the nitric oxide, a quantity of highly heated air is obtained, though only a small quantity of the energy contained in it can be used for other purposes. It has frequently been attempted to calculate how far the process of electric oxidation of nitrogen can be improved. In these calculations a definite temperature to which the entire mass of gases is heated is assumed, and then the quantity of nitric oxide obtained at this temperature is compared with that which should be obtained according to purely theoretical considerations; such calculations are entirely empirical of course. They have only very slight practical value, for in none of the processes working with electrical heating is the entire quantity of gas brought to a uniform temperature and no exact figures showing the actual distribution of temperature in the gases are known, so that we cannot determine how far the yields obtained correspond to those theoretically possible.

It has already been explained that the air blown into the actual furnace tube is subjected to a preliminary heating. The degree to which this can be taken, is a pure technical question depending principally upon the durability of the apparatus. If the preliminary heating is effected in iron tubes, it is not well to go above 500° C. Now the best yields are to be obtained if the air which has been raised to a high temperature by the preliminary heating is directed to the axis of the furnace tube, so that it enters the actual reaction zone whilst this nucleus of heated air is surrounded by a mantle of colder air. This can readily be effected by the aid of our process by a suitable arrangement of the air supply, for instance immediately above the electrode we blow in hot air and considerably higher up the tube cold air. The heavier cold air remains outside near to the wall of the tube in consequence of the whirling motion.

If a balance sheet of the entire heat obtained from the furnaces be made, it is seen that in round figures 40% of the energy supplied to the arc flame is obtained in the form of hot water, 17% is lost by radiation, 30% is used in the steam boiler, and 10% more has to be withdrawn from the gases after they have passed the boiler by cooling with water, whilst only 3% is actually used for the production of the nitric oxide. The heat that is used for the production of hot water and steam could be utilized in other ways. The steam is used for evaporating the solution, so that no other source of heat is required in the manufacture except the electrical energy. It is to be expected that in this matter of utilizing the heat in the gases further advances will be made. We have considered, for instance, the idea of building our furnaces directly inside a steam boiler, but have not adopted this plan.

I have now described the main outlines of the process of the Badische Anilin- & Soda-Fabrik. It can be seen that it utilizes very simple means. The furnace consists essentially of a system of pipes. They are cheap, reliable in actual manufacture, and last a long time. There are no moving parts and no expensive electro-magnets. The apparatus permits of the use of large units in manufacture and splendid yields are obtained. Besides this, this process furnishes the nitric oxide in a far higher concentration than most other processes. This is a point of great importance for the absorption, as to which I have still a few words to say.

We have seen that, for theoretical reasons, a sudden cooling must succeed the heating of the air. It is sufficient if this cooling is effected down to a temperature of about 1200-1500° C. At this temperature the rate of decomposition is already so low that it causes no further difficulty to remove from the gases the heat they contain without any further essential loss of nitric oxide. As a matter of fact the gases leave the actual flame tube of our furnace with a temperature of about 1200° C., and at the entrance to the gas flue common to all the furnaces they have a temperature of about 850° C. Directly the temperature sinks below 600° C., the colorless nitric oxide combines with a further quantity of oxygen taken from the excess of air present, whereby it is converted into nitrogen peroxide, $N O_2$, a gas having a brown-red color. Complete conversion only takes place below 140° C., and takes a considerable time. The velocity of reaction becomes slower the more nearly it approaches completion, that is to say, the smaller the concentration of the nitric oxide in the gas mixture; a mixture of gases containing two per cent of nitric oxide cooled down to 20° C. requires 12 seconds for the oxidation of half of the nitric oxide, but 100 seconds are required until 90% of the oxidation is effected.

It is necessary to absorb this nitrogen peroxide, the brown-red vapors that can readily be seen in the demonstration pipes, or rather in the bottles inserted into the pipe system for the purpose. It is not a simple matter to effect this removal of the nitrogen peroxide from the air. Alkaline liquids such as soda solution, milk of lime, and the like, combine with the gases forming equal proportions of a nitrite and a nitrate. This mixture can be used directly as a nitrogen manure. The statements that the admixture of nitrite is injurious to plant life are the result of a mistake. Von Lepel, Schloesing and lately Wagner have made

culture experiments which have fully proved that nitrite is not injurious to plants, and the nitrogen in nitrite is proved without doubt to be of equal value to plant life as is the nitrogen of nitrate. It is, however, impossible to use soda solution on account of its price, and the use of milk of lime for absorption purposes involves numerous difficulties. It cannot be applied in ordinary absorption towers down which the absorption liquid trickles, as the whole of the spaces in such a tower would very soon be stopped up. We have recently overcome the difficulties attending the absorption with milk of lime, and have succeeded in obtaining a calcium nitrite that has very valuable properties. It is to be manufactured on a larger scale so that already in the present season field experiments may be made as to its manurial properties. This salt is characterized by containing a large percentage of nitrogen—18%, whilst Chili saltpetre only contains 15%. The Norway saltpetre which has been brought into commerce by the Notodden-factory contains 13% of nitrogen. This new air-saltpetre may perhaps be destined to be the nitrogen manure of the future if the field experiments confirm the results hitherto obtained. If, however, it should be necessary to convert the nitrite into nitrate, this can readily be done.

At Notodden, where, as I have already mentioned, the oxidation is effected with Birkeland-Eyde furnaces, the absorption is not effected altogether with alkaline liquids, but water is principally employed. Nitrogen peroxide in contact with water behaves similarly as with alkalies, only in this case salts are not formed, but the free acids, that is to say a mixture of nitric and nitrous acid. The nitrous acid decomposes into nitric acid and nitric oxide, and this again in contact with air oxidizes to nitrogen peroxide. The absorption with water is, therefore, a somewhat complicated process and involves continuously a re-formation of nitric oxide, the quantity formed becoming continually smaller and smaller. It is consequently impossible to convert the entire quantity of nitric oxide into nitric acid by contact with water, or at least this would only be possible when using absorption vessels of monstrous size; consequently in the factories at Notodden the last portion of the nitric oxide is absorbed with soda, and in this way pure sodium nitrite is obtained, for a complete absorption can be effected with alkaline liquids if only half of the nitric oxide has been converted into nitrogen peroxide. The mixture of NO and NO_2 behaves as if it were N_2O_3, the anhydride of nitrous acid, and the absorption takes place, nitrite alone being formed. There is a demand for nitrite in the chemical industry, in which it is mainly used for the production of azo dyes.

If desired, the entire quantity of nitric oxide produced in the furnace can be converted into nitrite by working according to the process of our German Patent No. 188,188. We work in this way in our Kristianssand factory. There the nitrite is manufactured which is used in the Ludwigshafen factory of the Badische Anilin- & Soda-Fabrik. Sodium nitrite was hitherto obtained by the reduction of Chili saltpetre with lead; this method of production will soon cease to be practiced. It must, however, be borne in mind that the market for nitrite is very limited; its production will never be of ony considerable importance for the artificial nitrate industry. It will be possible by the use of about 12,000 hp. to produce all the nitrite required in the whole world.

When absorbing with water, the more perfect the oxidation of the nitric oxide to nitrogen peroxide is, the more nitric acid will be formed immediately on absorption, and it is therefore advisable to insert between the cooling apparatus and the first absorption apparatus a so-called oxidation vessel in which the gases remain for some time and can consequently become converted as fully as possible into nitrogen peroxide. The problem of absorbing the nitrous gases may at first sight appear a simple one, but besides the difficulties that have already been mentioned it involves others. The large quantities of air that have to be dealt with make it necessary to use rather large absorption chambers in order to wash the nitrous gases out of the air. The difficulties increase, as might be expected, with the degree of dilution in which the nitric oxide is obtained, and it can readily be understood that of two processes which use equal quantities of energy for the production of the same quantity of nitric oxide, that one will be the more valuable which yields the gases in the most concentrated form.

A large number of suggestions have been made with the object of simplifying the absorption. Absorption with concentrated sulphuric acid can be very readily effected. The product obtained is nitric acid and nitrosyl sulphuric acid, but no method is known of converting the nitrous gases from this sulphuric acid in a simple way into another compound, so that this method of absorption can only be used where there is direct use for nitrous sulphuric acid. It has been suggested to absorb the nitrous gases from the mixture with air by absorption with bodies which upon subsequent heating give the gases off again in a concentrated form. This method is neither new nor has it any technical advantages. Another suggestion is to cool the air containing the nitrous gases so as to liquefy or even solidify the nitrogen dioxide. For this purpose a complicated apparatus is necessary, and it involves compression of the gases, so that in my opinion it is not suitable for manufacture on the large scale.

It is, however, to be anticipated that there will be many improvements made on this problem of absorption. The process that Schlœsing has patented is of interest. The nitrous gases are absorbed while still hot with quicklime in the form of briquets. At first calcium nitrite is formed, but this, under the continuous action of air and nitrous gases, is converted into nitrate, so that the final product directly obtained is calcium nitrate in the solid state.

By bringing the nitrous gases in contact with water, as is done at Notodden, a dilute nitric acid results.

It cannot readily be obtained of a higher strength than 30—40% by direct absorption. In order to prepare concentrated nitric acid from this, any of the known ways can be used, for instance, by distillation the dilute nitric acid can be converted into 60% nitric acid. Upon repeating the distillation, adding some agent to combine the water, for instance concentrated sulphuric acid, or dry calcium nitrate, this can be converted into a concentrated nitric acid. The Salpetersäure-Industrie-Gesellschaft has taken out a patent for a process for concentrating nitric acid electrolytically, but I cannot think that this process will work more cheaply than the other process. In the literature there is a statement to be found that by mixing water vapor with the nitrous gases the condensation to nitric acid can be simplified, indeed it is stated that in this way fairly concentrated nitric acid can be obtained; this is not the case.

The direct conversion of the nitrous gases into nitric acid without the intermediate reformation of nitric oxide, which is the cause of the slow procedure of the absorption, can be effected by means of ozone. With the aid of ozone, indeed, the anhydride N_2O_5 could be produced. A cheap method of producing ozone might essentially simplify the absorption.

As a rule, when it is desired to produce nitrate, the dilute nitric acid is simply poured without any further treatment on to limestone, calcium carbonate. In this way a solution of calcium nitrate is formed. This is the method of procedure at Notodden. This dilute solution of calcium nitrate is evaporated down in a vacuum apparatus by the aid of steam produced with the hot gases that leave the electric furnaces. No fuel has been used at all.

When the solution has been sufficiently concentrated it is allowed to solidify, and the crystalline cakes obtained are ground to powder. The lime-saltpetre thus obtained is packed in wooden barrels containing 100 kg. (about 2 cwt.). Packed in this way it comes into commerce in a uniform quality containing 13% of nitrogen, and has already been known for a few years as Norway saltpetre.

The new industry requires a very cheap power, but apart from this hardly any other requirements need to be fulfilled. The industry can flourish where no other could exist, and is, therefore, well calculated to perform the part of a pioneer in the service of industry and to open up far-off districts to industrial pursuits. At the present time, as a matter of fact, only a very small proportion of that part of the sun's energy which raises water from the sea and deposits it on the mountains, whence it runs in countless streams back to the sea, is used for producing power. The reason is that up to the present there was no industry for which cheap power was the sole essential, and which at the same time could use enormous powers. In most industries the position, the site of manufacture, the supply of raw materials, or factors of that sort are far more important, and for many decades or even centuries most industries will be dependent upon coal.

It is almost superfluous to mention that the new industry is not restricted to the manufacture of nitrates. On the contrary, in the first place nitric acid will be manufactured, for in this form the nitrogen possesses a far greater value than in nitrate. Nitric acid is used in many industries, to the largest extent in the manufacture of explosives, but it would be reckless calculation which only paid attention to the production of nitric acid and did not regard the price of nitrate. Only when the manufacture of nitrate can be profitably undertaken, has the industry prospects of survival.

In this new nitrate industry for the first time a great industry has been established for which cheap power is the principal factor, and it is an industry which at the same time can utilize practically unlimited quantities of energy, for the product which is obtained is certain of rapid consumption which is constantly increasing. This utilization of large quantities of energy has been represented as a disadvantage of the new industry by several critics. It is incomprehensible to me how this can be done, for the success of every industry, the relation between the cost of production and the selling price is the final deciding point, but it is altogether a matter of indifference what are the items which constitute the cost of production. Indeed it might almost be stated that the position of the new industry is particularly strong, because the principal expense is the cost of the water power, for this will be obtainable in future decades also at the same price as now, whereas wages, the price of coal and other raw materials which are of far greater importance in other industries are constantly increasing. If the question of waste of energy is to be raised, it must be said that those truly waste energy who use the energy of the sun that has been stored up during past epochs in the coal measures, converting only a small proportion thereof into actual work and allowing the rest to go to waste. Those again are wasting energy who in a short-sighted manner and out of over-anxiety oppose the harnessing of unused water powers by the young rising nitrate industry for the reason that later on perhaps it would be possible to use the power to greater advantage; in the meantime, however, the water is permitted to run down the hill unused, and untold millions of wealth go to waste in this way. The new nitrate industry will present technical electricians with a series of new problems, and will suggest a large number of inventions. At the present moment we are but at the beginning, but at a very promising beginning, and when the history of the epoch of the white coal comes to be written, the first pages will have to be devoted to a description of the artificial nitrate industry.

The Porto Rican agricultural experiment station reports that Java coffee growing is now being introduced into the island to meet the demand in the United States for "a highly flavored aromatic coffee."

THE LABORATORY

AN APPARATUS TO TEST STRONG AQUA AMMONIA.

By W. C. KLOTZ.

When making tests of the strength of high percentage aqua ammonia by means of a hydrometer, the strong fumes of the liquid are always a nuisance to those near by, to say nothing of the loss in strength of the sample. A piece of apparatus to obviate these drawbacks, and which is at the same time useful and convenient, can easily be constructed as follows:

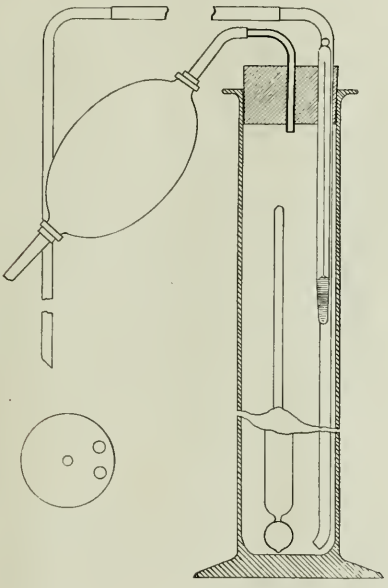


Fig. 1. Fig. 2.

Diagram of Apparatus for Testing Strong Aqua Ammonia.

A plain unlipped glass cylinder, about 2 inches in diameter and long enough to permit about 3 inches clear space above the top of the hydrometer when resting in the bottom of it, is supplied with a tightly fitting rubber stopper perforated with three holes, one in the middle, and two on the side, (Fig. 1). In the middle hole is placed a short right angled glass tube of small bore, extending just through the stopper. Through one of the side holes is drawn a long glass tube extending to the bottom of the cylinder, where it is bent slightly inward to facilitate the flow of liquid. The upper end is bent at right angles, and is attached to a rubber tube terminating in a glass sampling tube. The rubber tube is of a length sufficient to allow a sample to be drawn from a higher level than that on which the cylinder stands, and the sampling tube should be long enough to reach to the bottom of the bottle or vessel containing the aqua to be tested. In the other side hole is placed a thermometer, extending far enough into the cylinder to obtain the temperature of the aqua at the moment of reading. A two valve rubber bulb, to each end of which is attached a short rubber tube, completes the apparatus. (Fig. 2).

To make a test, put an accurate hydrometer into the empty cylinder, press the rubber stopper containing the glass tubes and thermometer firmly into place, taking care that the long tube runs down close to the side so that it will not interfere with the motion of the hydrometer. The apparatus must be on a lower level than the container to be sampled. Attach the suction end of the bulb to the middle tube, place the sampling tube in the aqua, and by gentle suction start the syphon, removing the bulb when the flow has commenced. As soon as the hydrometer floats freely, withdraw the sampling tube, and take the temperature and specific gravity readings. To return the sample, attach the pressure end of the bulb to the middle tube, and by pressing, force the liquid out of the cylinder again. By raising and lowering the sampling tube while the cylinder is filling, a perfectly homogenous sample may be obtained. The small amount of fumes issuing with the air displaced while the ammonia is running into the cylinder, is negligible when compared with those encountered in the testing in an open cylinder, and may be trapped if desired.

With such an apparatus one can obtain an accurate test of the average contents of an ammonia container, without loss of ammonia, and with practically no odor.

Accurate statistics of the sources of supply of crude rubber are almost impossible to obtain, as the figures available are necessarily mostly estimated. These figures, however, have a relative value for the manufacturer of rubber goods. The following is the approximate supply, in tons: Amazon River with its tributaries, 39,000; other districts of Brazil, 2,800; Federated Malay States, Ceylon and Sumatra, 4,600; Belgian Kongo and French Kongo, 5,600; Portuguese West Africa, 2,900; West Coast of Africa, 9,500; Rangoon, Penang, Borneo, etc., 1,200; East Coast of Africa, Mozambique and Madagascar, 800; Mexico, East Indies and Central America, 1,500; total, 67,900.

A NEW PYROMETER.*

By CHARLES E. FOSTER.

As a broad proposition it is hardly necessary to insist upon the need for pyrometers in the control of heating processes. Since prehistoric times, heat has been applied to produce change or destruction in materials under manufacture. This tendency of heat to produce change is a source of trouble when the design of a pyrometer is considered. The heat must change the nature of some part of the material manufactured, but in order to be continually reliable the pyrometer must not be subject to change as the result of the heat. Those pyrometers in which a part of the instrument is raised to the actual temperature to be measured must therefore have very definite upper temperature limits, and their life will be very short when used at high temperatures.

These considerations have called into existence a class of instruments broadly known as radiation pyrometers. A radiation pyrometer can be used at the highest temperatures attainable because no part of it is subjected to the actual temperature measured; it works entirely at a distance.

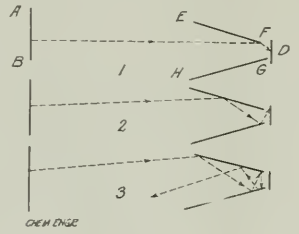


Fig. 1.

Radiation instruments may be divided into two main classes; first, those in which the measurement is made by means of the luminous radiation (these are called optical pyrometers), and secondly, those in which the whole of the heat radiation is used, these being known for distinction as total radiation instruments. It is the latter class only which will be considered here.

For general information on the subject of radiation pyrometry, I cannot do better than refer to the translation, by G. K. Burgess, of Le Chatelier's book, "High Temperature Measurements."† In this book also will be found much information on the early history of radiation pyrometry. There are, however, two applications of radiation methods which, I believe, are not there mentioned, but which are of some structural interest.

Melloni, in his apparatus for study of the laws of radiant energy, used a conical reflector to concentrate the heat rays emanating from the hot body, and near the apex of the conical reflector, a thermopile as the sensitive body. Fig. 1 shows such an arrangement diagrammatically.

The line *AB* represents the surface of the hot body. *EFGH* is the conical reflector and *D* the sensitive surface of the thermopile. It will be seen that the use of a conical reflector involves the possibility of multiple reflections. A heat ray such as 1 reaches the thermopile after a single reflection, while one such as 2 suffers double reflection. In the case of 3 the ray never reaches the apex at all.

From this it is evident that a conical reflector may be a very inefficient heat concentrator. At each reflection the ray loses a fraction of its energy due to absorption and dispersion. Some of the heat absorbed by the reflector is conducted towards the apex of the cone and it is there radiated directly on to the thermopile. This heat condition will take time and consequently, though it will add slightly to the total efficiency of the reflector, it has the great practical disadvantage of making the thermopile slow to reach a maximum and slow also to cool down again.

A second historical item is due to H. L. Callendar. In this case there is no heat concentration. The sensitive device is a pair of grids of platinum wire. These are enclosed in a glass vessel from which the air is partly exhausted. One grid is blackened while the other is left bright. When radiant heat falls on such a device the blackened grid will absorb more heat and will get hotter than the bright grid. The difference of temperature will be accompanied by a corresponding difference in electrical resistance which may be measured with a Wheatstone Bridge. This device, which is similar in principle to the Langley Bolometer, has been applied to the measurement of solar radiation. H. L. Callendar described its use on a furnace in his U. S. patent of 1898.

The history of the radiation pyrometer is brought down to about 1904 by G. K. Burgess and includes the description of C. Fery's pyrometer. This instrument is well known in metallurgical work, and need not therefore be fully described here. It is sufficient to say that it is a reflecting telescope with a thermocouple junction at the focus. In order to render this instrument available at different distances it has an eyepiece and a pair of subsidiary mirrors to guide the user in focusing it.

Undoubtedly the Fery pyrometer was the first practical total radiation instrument. The heat concentrator is a concave mirror, gilded on the face. It is very efficient for the following reasons:

1. Each heat ray suffers only a single reflection.
2. Glass allows high polish of surface.
3. The gilding gives the highest reflecting power, particularly for the invisible heat waves.
4. The focus is definite, giving a high degree of concentration.

*An address delivered before the Franklin Institute and printed in the Journal of the Institute.

†High Temperature Measurements, by H. E. Le Chatelier and O. Boudouard, translated by G. K. Burgess.

For these reasons the Fery pyrometer can be used where the hot body is small or the working distance great. The necessity for the eyepiece and focusing mirrors adds, of course, to the cost in manufacture and calibration.

In 1907 C. B. Thwing designed a radiation pyrometer having a long cylindrical casing with an opening at the end presented to the hot body. At the other end was a conical reflector and thermopile similar to that used by Melloni. This design obviated the necessity for focusing since a conical reflector of this kind has no definite focus. It has, unfortunately, the disadvantage of low efficiency and sluggishness, probably due to the multiple reflection mentioned previously.

It is here worth remarking that the indications of such pyrometers as Fery's or Thwing's are read on a millivoltmeter which measures the electromotive force set up in the thermocouple or thermopile. This being so, the lower the efficiency of the receiving part the more sensitive must be the millivoltmeter. Sensitiveness in a millivoltmeter is generally accompanied by delicacy and high cost, therefore high efficiency in the receiving portion is very much to be desired.

About the same time, 1907, C. Fery introduced a modification of his pyrometer. The thermocouple junction was replaced by a very small bimetallic spiral as the sensitive body at the focus of the concave mirror. This spiral was made of two metals of different coefficients of expansion so that, when heated by the focused radiation, it uncurled. A very light pointer attached to the spiral rendered the uncurling visible on a scale calibrated in temperature.

The gilded concave mirror is a desirable point because of its high efficiency, while the focusing mechanism is at times a disadvantage, particularly when the instrument has to be put into unskilled hands. To take advantage of the first property and avoid the second I designed the arrangement shown in Fig. 2.

The casing has at one end an aperture *EF*. At the opposite end is a gilded concave mirror *C*. One of a pair of conjugate foci of the mirror is at the aperture *EF* while the other is on the sensitive device *D*. Therefore there will be thrown on *D* a focused image of the aperture *EF*. Since the relative positions of these three essential parts are fixed, there is no focusing needed in use. For this reason it has been called the "Fixed Focus Pyrometer." The only condition that must be satisfied is that the aperture, as seen from every point of the mirror surface, must be filled by the hot body under test. This condition is satisfied if the hot body coincides with or overlaps any section of the cone *GAB* or any extension thereof. In the instrument on the table the position of the apex *G* is marked by the center ring. The directions for use are, then, that the distance from the hot body to the center ring must not exceed a certain constant multiple of the smallest dimension of the hot body. In the case here the multiple is ten, that is to say, with a hot body whose diameter or other smallest dimension is 6 inches, the working distance, as measured from its surface to the center ring, must not be more than 60 inches. Any smaller working distance will not alter the reading, provided the body is uniformly heated. The only result of bringing the hot body *AB* closer would be that its outer edges would be out of the measurement, consequently the user is not called upon for accurate judgment or measurement of distance.

For work on extremely high temperatures the proportions of the cone *GAB* can be altered so as to allow working at greater distances.

In the example here shown the sensitive device is a

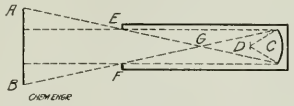


Fig. 2.

very small thermocouple. The heating of the junction where the two elements are joined together by the focused radiation generates an electromotive force, and this, or rather the resulting current, is read on a suitably calibrated milliameter. The calibration is made direct reading in temperature.

It is interesting to note that without involving inconvenient dimensions the electromotive force developed at 2400° F. exceeds that which would be given by a Le Chatelier thermocouple inserted directly into a furnace at that temperature. Since the thermocouple in the receiving tube is of low and constant resistance the rest of the circuit may also be of low resistance. This allows the use of an indicating instrument of very ro-

Surface	→ ▯	→ ▯	→ ▭
Crucible Clay	38	10	2
Iron Oxide	51	13	2
Platinum	84	21	4

CHEMENGR

Fig. 3.

(Note: Corrections in degrees to be added to "black body" temperature of 1000° C.)

bust construction. Another advantage of this type of instrument is that the mirror in the receiving tube is well protected from dust and fumes because it is situated at the bottom of a long closed tube.

As indicating the order of accuracy to be expected, a certificate issued by the Bureau of Standards, Washington, may be quoted. The instrument tested was one of the first of this type made and no unusual care was taken in its calibration. The results were given to an accuracy of the nearest 20° F. and at only two points at the top of the scale were there any corrections greater than this limit of test accuracy. In all cases the corrections were less than 2 per cent of the temperature reading.

For the general theory of radiation pyrometry, I will refer again to Le Chatelier's book and need not dwell on it here. It may be of interest, however, to consider the subject of what is known as "black body" correction. The meaning of the term "black body" is one devoid of reflecting power. Kirschoff in his study of radiation laws conceived such a body. The nearest experimental realization is the inside of a uniformly heated space as viewed through a comparatively small opening. An alternative realization of the "black body" would be one out in the open whose surface is quite without reflecting power. An ordinary furnace viewed through a small door or peep-hole will give a very close realization of Kirschoff's "black body." Again, many substances met with in practical manufacturing give fairly close approach to the same conditions.

The bearing of these theoretical considerations on the practical application of a radiation pyrometer is as follows: If the hot body is out in the open and its surface has appreciable reflecting power the radiant energy it gives out will be less than that of a theoretical "black body." The higher the reflecting power the greater will be the difference in reading on a radiation pyrometer.

At first glance this consideration appears to put serious limitations on the use of radiation methods. Happily this is not so in practice.

In the first place, no matter how large the departure from the true black body, the energy emitted by the hot body will bear a definite relation to the true temperature when the conditions are constant. Therefore, the readings of the pyrometer will be consistent and serve quite well to define the temperature. It is consequently evident that the indicating instrument can be specially calibrated to read true temperatures for any defined conditions of use, and this is very often done successfully in practice.

In the second place, as stated previously, the interior of a furnace that is fairly uniformly heated will realize the "black body" very closely. Since so many manufacturing processes call for the measurement of the temperature inside furnaces, the ordinary calibration for a radiation pyrometer is made on the assumption that it is to be used on a "black body." It is here important to remark that the optical pyrometer is in the same case with the total radiation instrument in this connection.

With a view to showing the order of magnitude of the black body correction under different conditions, and with different substances, I have made a few calculations. I do not claim very high accuracy for the numerical corrections employed but I believe them, at any rate, to be close enough for practical purposes.

I have taken three substances, crucible clay, iron oxide and polished platinum. I have then assumed each to be exposed, first out in the open, next in a shallow uniformly heated recess, of which the depth was half the diameter, and lastly in a deeper recess, also uniformly heated, whose depth was one and a half times its diameter.

The formula used in the calculations has shown itself to be at least approximately true.

$$T_2 - t_2 = t_2 \left\{ \frac{T_1}{t_1} - 1 \right\} \left\{ \left(\frac{A}{180} \right)^2 \right.$$

T_1 is the true temperature of a hot body when its black body reading is t_1. T_2 is the required true temperature for a black body reading t_2. A is the angle in degrees subtended by the opening in the recess from any point on the surface of the radiating body.

The temperatures in the formula should be absolute temperatures and the difference between T_1 and T_2 should not be very large. However, the result of applying the formula to 1000° C., using the correction derived from 700° C., does not introduce a serious error.

The results have been worked out to the nearest whole degree, and are shown in Fig. 3. It will be seen that placing the body in even a shallow recess reduces the correction very largely, while in a deep recess the correction becomes practically negligible. A furnace, even with the door wide open, gives conditions as good as those in the third case.

Fig. 3 shows that crucible clay gives a better approach to black body than iron oxide, a result that is, at first sight, surprising. I believe a possible explanation may be found in the second condition assumed in the table. If the surface of the clay is examined under the microscope it will be found to have a more or less granular structure. Though each crystal is highly reflecting, the surface as a whole will consist of an aggregation of recesses, having roughly the proportions of the second case, and would therefore collectively act as a fairly good black body.

According to a consular report the imports of paper and paper manufactures into Canada during the fiscal year 1908-9 were valued at $3,651,318, as compared with $1,408,209 in 1900, showing an increase during the decade of $2,242,109. The following statement shows a few of the leading classes of paper imported, together with their imports from the United States and the United Kingdom in 1908-9:

Articles.	Total.	From the United States.	From the United Kingdom.
Wall paper	$215,945	$154,819	$45,051
Papetrie and other manufactures	1,055,279	741,538	204,206
Printing paper	374,986	195,580	178,264
Ruled, bordered, coated and boxed	100,504	61,112	21,954
Tarred paper	295,934	281,938	12,350
All other paper	1,608,670	980,806	375,329
Total	$3,651,318	$2,415,793	$837,154

METALLURGY.

ELIMINATION OF SMELTER FUME AT THE PLANT OF THE UNITED STATES SMELTING CO., MIDVALE, UTAH.*

By LERAY A. PALMER.

(Concluded from the April issue.)

Reverberatory Roaster.—It has been proved that the matte from blast furnaces cannot be treated so successfully in converter roasters as in hand-rabbled reverberatory furnaces, the elimination of the sulphur in the converter roaster being only about three-fourths as much with the matte as with the raw ore. There are five reverberatory furnaces in operation, three on common matte and two on enriched matte. Each furnace is 60 ft. x 18 ft. x 6 ft., with a daily capacity of 12 tons. They are constructed in the usual way of brick braced by I-beam buckstaves, and with doors in the side for rabbling the charge. The matte coming from the blast furnaces carries about 23 per cent sulphur and is roasted down to 5½ per cent, an elimination of about 75 per cent of the sulphur. Care is used to keep the heat low in these furnaces so as not to sinter, but merely to soften the charge and permit it when drawn to be tamped solid in pots. Common matte is resmelted in the blast furnace and the enriched matte is treated in a copper furnace.

The blast for the roaster department is supplied by an American Blower Co. centrifugal fan direct-connected to a 100-horsepower Westinghouse induction motor making 1,120 revolutions per minute. The main air line has a diameter of 30 inches. A 20-ton Morgan electric crane serves the hand-roaster building.

Neutralizing Roaster Fume.—The fume from the converter roasters is carried by the 8-foot balloon flue to a rectangular brick flue. Adjacent to where the balloon flue enters the brick flue is a brick furnace 20 ft. x 8 ft. x 6 ft. which discharges its fume into the brick flue where it mingles with the roaster gases. This furnace is fired with slack coal placed over a layer of lime rock, and a small amount of the zinc concentrate is added. Air under a pressure of 8 ounces is blown into the furnace and keeps up a brisk fire as the fuel and lime are charged in thin layers. Under the influence of the blast the zinc sulphide rapidly oxidizes and passes into the dust chamber where it meets the roaster gases charged with SO_3 and neutralizes them, the two uniting to form the harmless and non-corrosive zinc sulphate. After leaving the roaster building the brick flue is built in the form a caternary curve 20 feet at the base, and this form is maintained until the flue enters the fan house.

The fume from the reverberatories is taken off in a balloon flue 5 feet in diameter which discharges outside of the building to a rectangular flue. The gases escaping from these roasters have much higher temperatures than those from the converter roasters and if delivered to the bags without cooling would destroy them in a very short time. To prevent this, a system of cooling tubes has been established. Instead of passing the gases directly through a brick flue they go through a series of brick chambers 10 feet long connected by twelve 24-inch steel pipes, the chambers being 20 feet apart. There are eight such sections and the increased radiating surface, combined with the great radiating properties of the steel, cools the gases so that subsequently, when they enter the flue which conveys the gases from the converter roasters, they are at the temperature required for safety. The last portion of the flue from the reverberatories is of steel 40 inches in diameter, dividing into two 30-inch flues before entering the catenary flue. The neutralization of any SO_3 in these gases is ensured by the introduction of crushed lime into the flue. All of the flues, both brick and steel, are provided with doors for the removal of the dust, and the cooling tubes have hand holes.

The Bag House.—The bag house is a brick structure 283 feet long, 58 feet high, and 60 feet wide. It consists of eight separate compartments or bays, three for the roaster gases and five for the blast-furnace gases. It is divided horizontally into two floors, the basement and the thimble floor. A broad runway surrounds the building at the thimble floor and another at the level of the shakers. The basement is reached from the ground. Each bay is provided with door, three to each blast furnace bay and two to each roaster bay. The thimble floor is 16 feet above the basement floor, and from the thimble floor to the roof it is 42 feet. The bags are 33 feet long and 18 inches in diameter. Both cotton and woollen bags are used, but the cotton is being replaced by the woollen as fast as the cotton bags wear out. The longer life of the woollen bags, some of which last over a year, justifies the additional expense incurred by their installation. The blast-furnace bays contain 416 bags each and the roaster bays 420 bags each, giving a filtering surface to each bay of approximately 70,000 square feet. Each alternate row is spaced at 2½-foot centers, thus affording room for a man to pass each side of the double row and inspect the bags. The bags are tied around the thimbles at the bottom and are securely tied at the top to prevent the escape of solid matter. The bags are connected also to the shaking device, which consists of a series of arms extending half way across the chamber. These arms are connected to a short arm extending across each three rows which in turn is connected to a rocker

actuated by a lever outside the chamber. By the system of arms and rockers the bags are thoroughly shaken twice daily without anyone entering the chamber.

The filtered smoke from the roaster bays discharges through the main stack shown in Fig. 1, which is 10½ ft. x 235 ft. and entirely self-supporting, being anchored to the concrete base by means of twelve 3½-inch bolts. Each blast-furnace bay has its own stack 6 ft. x 100 ft. These stacks, with 350,000 cubic feet of gas discharging through them each minute present a remarkable appearance, for the only visible smoke is a very light vapor which is practically free from all solid matter. From a distance it is difficult to distinguish any difference between this stack and that of the adjacent smelter which is closed down.

As the draft from the stacks is not sufficient to draw the gases through the bags, they are first taken to the fan house and from there blown through the bags. The blast-furnace gases are taken up by a 25-foot Sturtevant fan direct-connected to a 150-horsepower Westinghouse induction motor wound for 440 volts and making 150 revolutions per minute. As the sulphur in the blast-furnace gases is in the form of dioxide, which is not corrosive, no neutralizing agents are needed. The roaster gases are taken up by a 25-foot Sturtevant fan direct-connected to a 150-horsepower, 440-volt, Westinghouse induction motor making 170 revolutions per minute. At the roaster fan there is a small plunger feeder and hopper for feeding the neutralizing agent to the gases. Tests of the gases are made for alkalinity and such variations made in the feed of the neutralizing agent as may be found necessary.

Recording thermometers are placed outside of the bag-house bays and a record taken with a mercurial thermometer every half hour. The ideal temperature for the blast-furnace gases is 70° C., and it must not exceed 90° C. The roaster gases should have the ideal temperature of 100° C. and the safety limit is reached with 120° C. In case the temperature goes too near the safety limit additional air is admitted to the fan until the gas has cooled. While the ideal temperatures are not reached for any extended time there is no trouble in keeping below the maximum temperatures.

The gases enter each bay through a 42-inch elbow. When a person desires to enter a bay, a gate valve in this elbow is closed and one in a 24-inch pipe is opened. The 24-inch pipe is connected to a 4-foot Sturtevant fan in the blower house, direct-connected with a 10-horsepower, 400-volt, General Electric induction motor, by which ventilation of that bay is effected during the withdrawal of dust. This fan discharges to whichever of the large fans handles that particular kind of gas. A recording pressure gauge is attached to the fan conduits and the pressure kept at approximately 12 inches of water, or 62.4 pounds per square inch.

The dust which shakes down from the bags is removed from the basement and retreated, the roaster fume going to the roasters and the blast-furnace fume to the arsenic plant. As the blast-furnace dust lies on the floor of the bag house it ignites through spontaneous combustion and burns to a loose sinter containing much arsenious oxide, As_2O_3.

At the arsenic plant are two Brunton arsenic furnaces, Fig. 4, and a refining furnace. One of these Brunton furnaces is used at a time and is closed down when it becomes necessary to remove the dust from the chambers. Each furnace consists of a circular steel shell 20 feet in diameter by 4 feet in height encased with brick. There are two fireboxes in front, in which a clean coke fire is maintained. The material from the bag house which is charged in this furnace averages about 32 per cent Pb and 22 per cent As. It is dumped into the hopper above the furnace and is fed as required on to a revolving hearth which makes a revolution in 8⅓ minutes. Above the hearth is a rabble arm with inclined blades by which the charge is stirred to expose the particles to the heat. The readily volatile As_2O_3 passes off in the fume, while the lead sinters

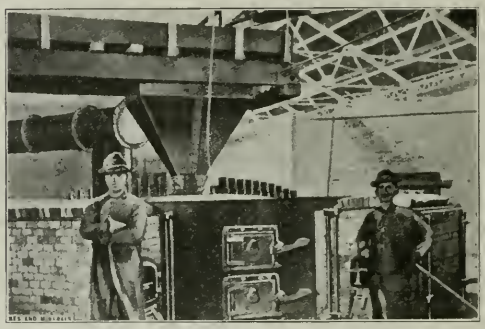


Fig. 4—Brunton Arsenic Furnace.

into lumps which fall over the edge of the hearth to the hopper, from which they are discharged into buckets outside of the furnace. The buckets are picked up by a monorail crane and taken to the cars which haul the material to the blast-furnace bins. This by-product of the arsenic furnaces assays about 40 per cent lead and 9 per cent arsenic.

The arsenic fume discharges into a settling chamber through a 24-inch flue. This settling chamber is 200 feet long, 20 feet wide, 10 feet high, for the first 50 feet, and 8 feet high for the remainder of its length. The chambers of the two Brunton furnaces have a common wall. At intervals of 8 feet in the chamber there is a brick baffle wall extending to the top and within 3 feet of the side wall. At each 16 feet is a door allowing access for the removal of the dust; the first five doors where the temperature is highest are of iron, and the other doors are of wood. The gases are obliged to take a zigzag course by the baffle walls and in so doing deposit the arsenic which is removed from the chamber in buckets and taken by the crane to the refining furnace. The product of this first chamber is 97 to 99 per cent pure arsenious oxide, As_2O_3.

The refining furnace is of the reverberatory type 25 ft. x 15 ft. x 6 ft., charged from the top through hoppers. Selected coke is used for fuel and care is taken that the fire be kept clean so that no dust may enter the hearth on which the arsenic is treated. The settling chamber for the refining furnace is of the same size and design as that for the Brunton furnace. Recording thermometers are placed at intervals on the outside and the temperature of the chamber is kept at about 500° F. at 30 feet, 200° F. at 100 feet, and 120° F. at 175 feet distant from the furnace. These thermometers are used chiefly as a check and the operation is governed by the quantity of arsenic being deposited. When none is found in the farther end of the chamber it is an indication that none is escaping with the fume. All fume from the arsenic furnace discharges in the dust chamber of the converter roasters, so that any escaping gas or arsenic goes again to the bag house.

The product of the refining furnace is in crystalline form and grinding is necessary to make a commercial product. This is done in a 3-foot diameter burr mill, which is simply an advanced type of the old style upper and nether millstone. The ground product is barreled and shipped. During the grinding operation an 8-inch Buffalo Forge Co. centrifugal blower is used to draw off the dust, discharging it to the settling chamber of the Brunton furnace.

The daily output of the plant is 2 tons of refined arsenic of exceptional purity, in fact, when the company bought some of the best grades of imported arsenic to use as the standard of their analyses they found that their own product exceeded the foreign in purity, and by that standard was over 100 per cent pure. An analysis for the impurities shows that it contains 99.87 per cent pure arsenious oxide.

Bath and change rooms are provided at the arsenic plant and bag house and all employes of either place are required to take a bath before going off shift. Some trouble was experienced at first in getting the foreign laborers to accept the rules regarding cleanliness, but once enforced they have been carried out without difficulty. The men working about the plant dress in one-piece overall suits with hoods that protect them, except for the face, over which a respirator is worn when it is necessary to approach the fume. With these precautions taken in dress and personal cleanliness no injury has resulted to employes of the plant.

According to Consul Church Howe, the annual report of the municipal markets at Manchester, England, shows the large amount of food unfit for human consumption detected by inspectors last year: Over 153 tons of meat were destroyed, also nearly 90 tons of fish, and some 24 tons of fruit, making a total of 267 tons, as well as large quantities of game, poultry, vegetables, etc. Three cases of anthrax were also detected, two being dressed carcasses, and one was on a farm within the city area. In the first-mentioned case, the meat had been consigned to the market.

MANGANESE DEPOSITS OF THE BLUE RIDGE.*

By L. G. LACKEY.

It is generally known that the most important manganese deposits of the United States occur in the Blue Ridge district of Virginia, this region having produced the principal tonnage mined in this country for many years, and the entire output of this class of ore for 1908 and 1909. It does not seem to be generally known, however, that only a few of the deposits found in Virginia have ever been thoroughly prospected or developed. In most cases this has been due to the fact that sufficient capital has not been available.

In many cases small pockets near the surface have been worked out and operations discontinued without further exploration. In the Blue Ridge, manganese occurs in small, scattered pockets near the quartzite or country rock, where it is usually found intimately associated with the iron ore; but, on the same slope of the Blue Ridge along the foot hills and near the valley limestone, it is found in clay beds and is a persistent deposit following the strike of the country rock northeast to southwest.

This fact is demonstrated by the old workings at the Crimora mine in Augusta county and is confirmed by a recent development work at Happy Creek, Warren county, Va., where a deposit of considerable magnitude has recently been exposed. This deposit occurs near the contact of the Cambrian quartzite, and Shenandoah limestone, on the west slope of the Blue Ridge, in clay bed one-half mile in length and with an average width of 200 ft. Throughout this bed are found kidneys of black psilomelane and nests of crystalline pyrolusite imbedded in the variegated clays, and these nests or pockets are connected by seams of stringers of granular pyrolusite and wad. Overlying this deposit is a blanket formation of iron ore, 2 to 4 ft. thick, a wash from the heavy iron-ore deposits above.

A concentrating mill has been constructed at the Seibel mines, Happy Creek, Va., and is now turning out high-grade manganese ore. The capacity of the mill is 50 tons per day, and the principal output will be shipped to the steel mills in Pennsylvania, but some of the ore produced will be suitable for the manufacture of chemical, brick, paint, etc.

In many of the iron mines of the Blue Ridge there are pockets of manganese ores interbedded with the iron ores, which can be recovered as a by-product if proper provision is made for the recovery when constructing iron-ore concentrating plants. With the increased demand for manganese ores, there will be an advance in prices and a ready market for the output. This will lead to the working of many abandoned, small deposits, especially those found with the iron-ore deposits.

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*From the Engineering and Mining Journal.

THE MIXING OF FIRECLAYS.*

In the manufacture of firebricks and the great variety of articles made from fireclay many varieties of clays are used, each of which has its own peculiar characteristics. Exigencies of manufacture and the essential properties of the manufactured article often necessitate the use of two or more clays in combination. Further, most measures yield a variety of clays, some of which can be separated when brought to the surface, and manufacturers have to arrange mixtures from considerations of convenience and economy.

There are two methods of mixing, viz., the dry process and the wet process. Dry mixing is effected by grinding the clays together, or by first grinding them separately and afterwards mixing by hand or by machine. The completeness of the mixing will be governed by the fineness of the grinding, assuming, of course, that the clays are properly distributed with regard to each other.

The most efficient and thorough mixing is obtained by the wet process. In this process the clays are "blunged" together, passed over a lawn to take out any still undisintegrated particles, then put through a filter press or allowed to settle. This method is always used in the manufacture of pottery, on account of the evenness and intimacy of the mixtures it gives. In the manufacture of refractory articles the choice of method will depend on the conditions to be filled and on circumstances. The wet process is, however, too expensive except for special work.

The principal reasons for mixing clays are: Modification of the chemical composition, increasing refractoriness under certain conditions, the production of open or close "textures," or the development of certain physical properties. Part of the material may be used in the burnt condition, when it is commonly called "grog" or "chamotte," and other materials may be used, as coke dust, bauxite, graphite, aluminum hydroxide, etc. Also, as suggested in the first paragraph, mixing is sometimes necessary to produce a good working body, i. e., one that will dry and burn without twisting and cracking.

In most cases any admixture which may be contemplated will be expected to increase refractoriness, whether this is the primary object or not. It is, therefore, necessary to consider the properties which characterize refractory clays. Tests of refractoriness are made under standard conditions as far as possible. Whether under working conditions material comes up to the same standard as the clay from which it was made will depend on how far provision has been made for variations between the standard and working conditions. Herein lies the skill of the manufacturer.

The fact is often overlooked that refractoriness is a function of the physical as well as the chemical properties, both of which are definite for any particular clay in its natural state. So soon, however, as heat is applied these properties begin to change, and there is for each clay a temperature at which one or more of its component compounds begins to assume the molten state and to attack, and dissolve, other compounds in contact with it.

The rate at which the reactions proceed will depend on the temperature and on the character, physical and chemical, of the, as yet, unaffected constituents. If these reactions can be retarded by any means an increase of refractoriness is gained.

An example will make clear this point and others closely allied. Given two clays of which the analyses are as follows:

	I.	II.
SiO_2	52.50	67.18
Al_2O_3	45.21	27.51
Fe_2O_3	0.81.	2.52
CaO	....	0.53
MgO	0.54	0.28
Alkalies	0.51	1.90
	99.57	99.92

No. 1 is a hard shale, does not burn dense, is not very plastic, and in refractoriness is equal to Segar Cone 36.

No. 2 is a soft clay, which easily weathers, is fairly plastic, and is equal to Seger Cone 30 in refractoriness. The problem is to use these two clays in combination to make bricks or furnace lumps (leaving out of consideration crucibles and similar articles.) The brick is to be hard and compact in grain, and must resist alterations in temperature without "dunting."

Neither clay can be used alone. No. 1 is only slightly plastic, and even when ground in a wet pan makes but an indifferent brick.

No. 2 alone is not refractory enough, has too high a shrinkage, burns dense, and would crack ("dunt") on cooling. Its most useful property is its binding power.

Proceed by first burning No. 1, then grinding and sieving it to particles graded from ⅛ inch to 1-32 inch the exact limits of size depending on the class of article to be made. None of the fine flour from the grinding should be used. No. 2, raw should be ground quite fine. Mixtures may vary from equal parts of each clay to two parts of No. 1 to one part of No. 2, according to the binding power of the latter.

The mixing should be done on a clean floor by spreading the clay in alternate layers and sprinkling with water from a sprinkler or watering can. After the whole batch has been laid down it should be well mixed by shoveling and allowed to stand for a few days, covered over with wet cloths to keep the water from evaporating. After turning again with shovels it should be put through a pug mill.

The clay should be quite stiff when moulded, and so-called slop moulding avoided. This method, rightly carried out, will give a hard, compact tough body. The brick should be burnt to Cone 10.

*E. P. Page in Brick.

The CHEMICAL ENGINEER

HARRY McCORMACK, Editor.

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NOTES AND COMMENTS.

Material for Paper Manufacture.

The supply of material for paper manufacture has been a question receiving much attention of late. The supply of wood which is suitable for the manufacture of wood pulp in this country has been decreasing very rapidly, and it is only a question of time until the material available for this purpose will be exhausted. We have lately been drawing largely upon Canadian supplies to make up our deficiencies. Canada has, however, recently put into effect a tariff on wood pulp which will increase the cost of our material for this source. The rates are to be as follows:

On mechanically ground wood pulp, one-twelfth of 1 per cent per pound, dry weight.

On chemical wood pulp, unbleached, one-sixth of 1 cent per pound, dry weight; bleached, one-quarter of 1 cent per pound, dry weight.

On printing paper, the regular rates, and in addition thereto the additional duty of one-tenth of 1 cent per pound when valued at 3 cents per pound or less.

Our chemists have been searching for an annual plant which will give a supply of material for paper pulp and, according to recently published acounts, their search is about to be successful. The chemists in the employ of the Department of Agriculture have been experimenting for sometime on the manufacture of paper from corn stalks.

Their work has been successful in that good paper has been made from this material at a price which will make it available. The disadvantages, however, of working on this material are that it is very difficult to properly comminute the dry corn stalks and after they have been comminuted all water soluble substances have to be removed by diffusion before the material can be cooked for pulp. This necessitates labor upon which there is no return, as this solution is valueless.

The same paper mill which has been carrying on the experiments in the manufacture of paper from corn stalks has also recently been experimenting on the manufacture of paper from bagasse with results which are very encouraging. In the sugar cane stalk, we find two constituents, known as the pith and the fiber. These materials differ considerably in their characteristics and in using them as paper stock some difficulties have been encountered in separating these materials, or in working with them when they are present together.

A method has recently been devised by which these materials are separated before coming to the paper mill, thus materially simplifying the process. It has been known for some time that bagasse would make first class paper.

The difficulties, however, in handling the material as enumerated above and also the difficulty of getting proper material when the sugar juice is removed from the cane by crushing have been such as to discourage all commercial efforts to manufacture paper from this material. Recent discoveries in the method of handling the cane have eliminated these difficulties and it now seems assured that this material will be available for paper stock. Recent statistics published on the quantity of cane sugar manufactured during the last year would indicate that about five million tons of this material is available, provided all of the cane fiber is made up into paper. These figures are based on a cane analyzing approximately half as much cellulose as sugar. This amount of material would go a long ways towards supplying our present deficiency in paper stock, as it would be available yearly.

Paper made from the fiber contained in the bagasse is of very high grade. Samples which have been shown to the writer are much above the grade of paper made from wood pulp, and the process of manufacture is simpler than for the wood pulp. The cane fiber cooks in less time and with less soda than the wood, it also bleaches easier. The paper made will compare favorably with any except that made from linen.

Need of Chemical Engineers for City Boards.

The recent investigations which have been conducted in a number of our larger cities, particularly in Chicago, on the supplies furnished the city for various purposes, such as coal, oils, castings, fire hose, etc., has brought to the mind of the writer in a rather forcible way the fact that many of our cities could with advantage use the services of a chemical engineer on their Board of Public Works, preferably holding a position as chairman on such board. Most of our large industrial enterprises have recognized the value of the services which can be rendered by such a man in drafting and enforcing proper specifications covering the purchase of materials.

The writer believes, however, that most of our cities have overlooked the opportunity for saving, which would be presented by adopting such a course. A large city will purchase, during the year, several million dollars worth of supplies which would properly come under chemical specifications.

Most cities now have departments of tests to look after the inspection and the analyses of various materials purchased. The difficulty, however, seems to

lie in the fact that the activities of these various departments are not intimately related and that the responsible head, usually a commissioner of public works or officer holding a similar title is not familiar with the duties involved in the proper inspection and testing of these materials and is therefore not in a position to intelligently interpret reports submitted to him by his subordinates. It is only necessary to cite the work of such a man as the late Dr. C. B. Dudley of the Pennsylvania R. R. to show what a properly trained man can do in the way of adding efficiency in the operation of a large corporation. With the development of our American municipalities there will come increased opportunities for such a trained man *not* in the service of, but as a responsible head of the public works of the municipality.

RECENT CHEMICAL PATENTS.

The following patents have been reported for the Chemical Engineer by C. L. Parker, solicitor of patents, McGill Building, Washington, D. C.

950,595. Process of *Reducing Metallic Oxid Ores.* Herbert E. T. Haultain, Toronto, Ontario, Canada, March 1, 1910.

950,677. Method of *Preparing Pure Lead Sulfate from Impure Sulfate.* Alexander S. Ramage, Buffalo, N. Y., March 1, 1910.

950,734. Process for *Manufacturing Incandescent Mantels.* Heinrich Sussmann, Berlin, Germany, March 1, 1910.

950,797. Method of *Manufacturing Whiting.* William Nelan, Akron, Ohio, March 1, 1910.

950,798. Process for *Sintering Ore.* Geo. G. Vivian, Tintic, Utah, March 1, 1910.

950,869. Process of *Producing an Amorphous Tungsten Powder.* Johannes Schilling, Colonie Grunewald, near Berlin, Germany, March 1, 1910.

The process consists in heating a tungsten compound adapted to be dissociated by heat in a non-oxidizing atmosphere to a temperature above the disruption temperature whereby the reducing agents separated from the said tungsten compound act upon the oxids of tungsten present.

951,072. Process of *Converting Carbohydrates into Hydro-Carbons.* Arthur Heinemann, London, England, March 1, 1910.

951,113. *Refractory Substance.* Friedrich Grossmann, Konigswinter, Germany, March 8, 1910.

951,155. Process of *Preparing Scouring and Other Household Soaps Containing Fullers' Earth.* Nathan Sulzberger, New York, N. Y., March 8, 1910.

951,198. Process of and Apparatus for *Treating Ores.* Walter G. Perkins, Smelter, Nev., March 8, 1910.

951,228. Method of *Decomposing Salts.* Jasper Whiting, Boston, Mass., March 8, 1910.

951,272. *Obtaining Petroleum Products.* Herman Farsch, New York, N. Y., March 8, 1910.

951,369. *Paint and Varnish Remover.* Peter J. Geller, Detroit, Mich. March 8, 1910.

951,385. Process of *Producing Alloyed Steel.* Frank L. Antisell, New York, N. Y., March 8, 1910.

The process consists in forming primary steel, introducing said steel into an electric furnace containing an alloying element and combining in said electric furnace the said steel and alloying elements to form an alloyed steel.

951,445. *Explosive Compound.* Hudson Maxim, New York, N. Y., March 8, 1910.

951,471. *Bituminous Cement.* Joseph H. Amies, Philadelphia, Pa., March 8, 1910.

951,666. *Manufacture of Modified Starch.* William Thomson, Manchester, England, and James A. Morrice, Glasgow, Scotland, March 8, 1910.

The method consists in placing ordinary starch in a vessel, exhausting air from said vessel, introducing thereto sulfur dioxid gas, heating the confined gas whereby to obtain pressure, and containing the heating at a suitable temperature, say between 100 and 105 degrees Centigrade, until the starch becomes modified.

952,069. *Composition of Elements to be Used for the Manufacture of an Improved Quality of Metal.* Charles R. Bryson, Pittsburg, Pa., March 15, 1910.

952,098. Process of *Obtaining Sulfur Dioxid.* Charles B. Clark, Bangor, Me., March 15, 1910.

952,150. *Rubber Compound.* Jerome Smith, Chicago, Ill., March 15, 1910.

952,245. *Art of Coloring Wood.* Levi S. Gardner, Otts Mills, La., March 15, 1910.

952,248. Method of *Oxidizing Atmospheric Nitrogen.* Henry Howard, Boston, Mass., March 15, 1910.

The method consists in compressing a gaseous mixture containing nitrogen and oxygen, subjecting the same in the compressed state to an electric discharge, then immediately expanding the entire body of highly-heated oxidized product and converting the heat energy into mechanical work, whereby a rapid cooling of the oxidized products is secured and the dissociation of the same is minimized.

952,260. Process for *Melting and Refining Iron.* Henry Johnson, Saxilby, England, March 15, 1910.

952,278. Process of *Preparing Mineral Fertilizers.* Eduard Pohl, Honnef, Germany, March 15, 1910.

952,290. *High-Resistance Iron Alloy. Willis R. Whitney,* Schenectady, N. Y., March 15, 1910.

952,351. Process of *Detinning Tin-scrap.* Walter J. Phelps, Baltimore, Md., March 15, 1910.

The process consists in subjecting the tinscraps to a sufficiently low temperature to disintegrate the tin, and agitating the scraps for separating the disintegrated tin therefrom.

952,391. *Steel Alloy.* Samuel S. Wales, Munhall, Pa., March 15, 1910.

952,484. Method of *Lixiviating Ores.* Cottfried Vervuert, Iwsbach, Germany, March 22, 1910.

952,560. Process of *Obtaining Ammonium Sulfate from Gases.* Nikodem Caro, Berlin, Germany, March 22, 1910.

952,585. Method of *Producing Copper-Zinc Compositions and Alloy* for the Production Thereof. Walter Rubel, Vienna, Austria-Hungary, March 22, 1910.

952,704. *Process of Making Antimony Compounds.* Paul Boessneck, Leipzig, Germany, March 22, 1910.

952,724. Production of *Plastic and Elastic Substances.* Ludwig Berend, Crefeld, Germany, March 22, 1910.

952,863. *Paint Composition.* Nelson B. Arnold, Westfield, N. J., March 22, 1910.

952,888. Process of *Creosoting Wood.* Patrick F. Dundon, San Francisco, Cal., March 22, 1910.

953,025. Process of *Fermenting Organic Nitrogenous Substances.* Jean Effront, Brussels, Belgium, March 29, 1910.

953,073. *Extracting Caffein from Coffee.* Heinrich Trillich, Munich, Germany, March 29, 1910.

953,094. Process for *Devulcanizing India-Rubber.* Moritz Korner, Grunau, Germany, March 29, 1910.

This is an improvement in the devulcanization of vulcanized India rubber by treatment with India-rubber solvent at a high temperature and under pressure, which consists in adding to the said treatment a treatment with water not containing alkaline substances for several hours at a temperature above 100 degress C.

953,196. Process of *Making Filamentous Lead.* Carleton Ellis, Larchmont, N. Y., March 29, 1910.

953,621. *Liquid Coating Composition.* Paul Jaeger, Stuttgart, Germany, March 29, 1910.

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THE PRINCIPLES OF VITREOUS ENAMELLING OF CAST IRON FOR INDUSTRIAL PURPOSES.*

By HAROLD HOLCROFT, M. A., F. R. P. S.

Up to the present time enamelling has been treated as a secret process, but seeing that much of the practice of enamelling is now common knowledge, the time has arrived when the subject can be discussed by those interested with advantage to all. One difficulty in the way of research which involves any considerable expense is the fact that the trade is but a minor industry, and perhaps likely to remain so.

Until recently the literature of enamelling for industrial purposes only existed in the Specifications of Patent Offices, or in scraps of no great importance in general literature. Silicates are now receiving attention, not only in their application to ceramics and glass, but also to some extent in their application to enamels on metals, and reports thereon are to be found in the transactions of the American Ceramic Society. A summary of recent work in Germany in the field of silicates has been published by Dr. Koerner in the "Sprechshall Kalender für die Keramischer, Glass, und Verwandten Industrien" (Müller und Schmidt, Coburg).

The application of vitreous enamels to cast iron is probably of French or German origin and dates from a time earlier than the beginning of the last century. Tradition asserts that cast iron vessels were enamelled in Alsace and Lorraine about this time, and probably also in the Rhine provinces of Germany.

In this country a patent was taken out by Hickling in 1799, and enamelled cast iron pots were made under this patent at the Eagle Foundry in Birmingham. This enamel appears to have been applied in one coat and to have contained a considerable percentage of lead compounds. The manufacture was abandoned after a short existence.

In 1839, T. and C. Clark, of Wolverhampton, took out a patent for a process in which the use of lead was avoided. This enamel consisted of two coats, the lower coat being a boro-silicate of relatively high fusing point, and the upper a more fusible glaze. The idea of using two coats, with the upper the more fusible of the two, appears to have originated on the continent, but Clark's process was a marked advance, in that the quality of the goods was much superior, and the use of lead in the enamelling of cooking vessels dispensed with. In the manufacturing process Messrs. Clark received great assistance from C. Machin, the manager in the enamelling department.

Two or three years later, Messrs. Archibald Kenrick & Sons, of West Bromwich, brought out a process upon the same principles, but differing in some important details. As a result of a long lawsuit between these two firms, a compromise was arranged upon equal terms, and today both these firms manufacture enamelled goods upon the original principle, but of course, with many improvements in detail. Of late years other processes of enamelling, differing in principle and composition, are in considerable use in the enamelling of baths and various miscellaneous and ornamental articles.

The trade is being specialized and developed for different purposes, but it still continues to be an adjunct or finishing process in several distinct trades. This will in part explain why it is that trained specialists do not appear to be generally employed in the works. The position is unfortunate but not uncommon. If any great scientific development is to take place, it is imperative that the expert should be in close touch with manufacture in bulk, for in no industry is there a wider gulf between successful laboratory experiments on a small scale and manufacture on a large scale, which brings to light many important matters which are otherwise overlooked.

The objects of industrial enamelling on metals are: (1) To provide a protective coat for the metal against corrosion, either by the atmosphere or anything which may be brought into contact with the enamelled article. (2) To provide a smooth surface which may be easily kept clean. (3) To provide a coat which will withstand a wider range of temperature than is possible with any varnish or Japan. (4) For ornamental purposes. (5) To provide an insulating covering for parts of electrical apparatus. (6) To provide a hard surface for parts of textile machinery which will not only resist wear from the passage of the material but prevent discoloration from contact with the metal.

The principal articles of commerce in enamelled cast iron at the present time are: (1) Culinary and household vessels, which are required to resist the solvent or destructive action of water, saline solutions, weak

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vegetable acids, weak alkaline solutions, or fatty substances, and may or may not be required to withstand moderate ranges of temperature. (2) Baths, lavatory basins, etc., which more especially should resist the action of soap. (3) Sanitary ware, soil pipes, etc., which are used at normal atmospheric temperatures. (4) Chemical vessels or apparatus which are specially designed to resist different agents. (5) Ornamental articles, some of which, such as the outside shells of gas fires, or other heating apparatus, have to resist a considerable range of temperature. (6) Miscellaneous articles, such as reflectors, insulated electric fittings, etc.

A vitreous enamel is usually a species of glass which is applied to the metal and fused thereon at a temperature ranging from a low red to a bright red heat, but in very exceptional cases the enamel may not contain any silicate at all. In general, enamel consists of a mixture of several silicates or boro-silicates, with the addition of other substances for special purposes. It is necessary for the enamel to have a comparatively low fusing point, since with cast iron the highest permissible limit of temperature at which the enamel shall fuse, must be low enough to obviate the collapse or deformation of the article by its own weight; which temperature will obviously vary somewhat with the shape and weight of the article. It is, however, desirable to have the enamel with the highest permissible fusing point, as the requisite qualities in the enamel are more easily attained than in the case of an enamel of lower fusing point.

In the fabrication and application of an enamel for any required purpose, the manufacturer is confronted with very many difficult problems, one of which arises from the fact that a combination is attempted of two materials of very different physical properties. On the one hand, the metal is a good conductor of heat, has a comparatively high co-efficient of expansion for heat, and is comparatively soft and resistant to shocks; whilst, on the other hand, enamel is a bad conductor of heat, is hard and brittle, and unless care is taken, has a lower co-efficient of expansion.

In view of the many conditions which have to be satisfied it must be recognized that as no enamel can fulfill every condition perfectly, the best enamel for any particular purpose must be the most judicious compromise of conflicting conditions.

If a chemist is required to report upon the merits of an enameled article, he should especially examine and test it to see if it fulfills the conditions for which it was designed. For instance, in the case of an ordinary enameled saucepan, which is manufactured for the purposes of cooking, the testing to which it should be subjected should be somewhat as follows: Continuous boiling with water for say 14 days. If it passes this test it should be subjected to continuous boiling successively for similar periods with weak vinegar, dilute citric acid, dilute solutions of sodium carbonate, and sodium chloride. If the enamel is attacked by these agents, or by boiling water, the polish or gloss of the surface will be replaced by a roughness more or less pronounced and easily seen when any deposits which may have been formed, have been carefully cleaned off. Milk should be allowed to stand in the cold in the vessel for a month, since milk and especially sour milk will attack some enamels which resist previous tests. The enamel should be tested for hardness, which should be sufficient to resist abrasion in ordinary cleansing operations. The manufacturer's rough testing for hardness is usually performed by scratching with pieces of steel of varying degrees of hardness, which are adopted as standards. The saucepan should then be broken into pieces with a hammer, and it should be noted whether the enamel adheres firmly everywhere to the fragments. In passing, it may be said that by variations in the way of hammering, considerable difference in the results can be obtained. The broken pieces should be examined to see if the coat of enamel is uniform and of reasonable thickness. A good enamel for a saucepan should be somewhat thin. Since enamel is a bad conductor of heat, with a thick coat of enamel the temperature of metal when heated rises much more rapidly than that of the enamel. This sets up strains, which sooner or later do mischief. A thick layer of enamel also considerably impedes the passage of heat to the contents of the vessel, so that by the time the fluid reaches the boiling point, the metal bottom of the vessel is at a considerably higher temperature. If, therefore, the vessel be removed from the source of heat, the moment the contents begin to boil, the heat accumulated in the metal bottom of the vessel, will cause the contents to continue boiling for some few seconds. The tendency to boil over is a frequent cause of complaint when the enamel is too thick. The other advantages of a thin enamel follow from a reduction of weight, and do not specially concern the chemist.

Another saucepan should be tested under reasonably rapid changes of temperature, such as are likely to be met with in ordinary use. Water should be raised to the boiling point in the vessel, which should be then rapidly emptied and cold water substituted: repeating this a few times. There should be no chipping or cracking. A more severe test than this is scarcely reasonable for these articles.

Enamel for cooking vessels should be tested by analysis for the absence of lead or other objectionable substances: but with cast iron cooking vessels of British manufacture, it is hardly necessary, as no British maker appears to use any objectionable ingredients in enamels for cooking purposes.

If the enamel appears to be composed of two distinct layers when the broken section is examined, the red ink test should be applied to ascertain if the lower layer of enamel is porous or not. If it is, the red ink will penetrate and will be visible from the upper surface. When the lower layer is porous, any liquid readily penetrates through any slight defect in the upper layer, and causes formation of rust, which sooner or later detaches the enamel from the iron.

The enamel for cooking vessels should be pure white in color, the surface glossy, perfectly smooth and free from defects. Crazing or spiderlike cracks, due generally to an error in the expansion co-efficient in the enamel, may be practically invisible at first, but will reveal themselves if the enamel is rubbed with any dark finely divided powder. Any test of a saucepan or cooking vessel with a strong acid or alkali is futile.

In the same way with all other enamelled articles, the chemist's tests should have regard to the especial use for which the particular article is designed.

It is found that comparatively small differences in composition produce marked differences in the physical properties of enamels, and in their capacity to resist various agents.

The results of the action of sulphuric acid upon enamel are sometimes curious. In some experiments made to produce enamels to resist this acid, one or two were found which would resist concentrated and also dilute (2½ per cent) acid, for some weeks at least, but at 50 per cent strength, the acid quickly destroyed the vessel. The greatest problem in producing large enamelled vessels to resist such agents, is not so much with the enamel itself, as in the difficulty of getting a perfect coat of enamel all over the surface of the metal; the most microscopic fault is fatal.

It is a fact which should be more generally known, that enamels have become highly specialized and different in their composition, physical properties and methods of application. In the enamelling of cooking vessels in this country, the industry is a perfectly healthy occupation for the operatives, from the absence of any deleterious materials in the composition, or dust in the working operations. On the other hand, in some of the other uses of enamels, there is need for proper precaution, and Home Office rules, which may be advisable in some cases, are quite uncalled for in others. The same manufacturers do not often produce more than one type of enamel.

Cast iron as a base for enamels, possesses one advantage, in that it forms a rigid support, and the enamel has not to withstand the strains of bending. In this respect it is much superior to sheet iron; but cast iron presents peculiar difficulties to the manufacturer in the application of the enamels. The chemical constitution of cast iron is not a matter of very great importance, except that a high percentage of graphitic carbon is not desirable, as the adhesion of the enamel is lessened. It is also desirable that the plumbago or other facing used in moulding the castings should be as small a quantity as possible for the same reason. The most important question in the enamelling of cast iron is whether the enamel is to be placed directly upon the natural skin of the casting, or upon a machined surface. Upon the machined surface many varieties of enamel can be applied easily, which would fail entirely if placed upon the natural skin. Enamelling upon the natural skin presents special difficulties, and requires special treatment. If the skin of the casting is not to be removed, it is most efficiently done either by a lathe or planing machine or an emery grinder, as neither acid pickle nor sand blast is found to be so effective for the purpose. This necessity in practice tends to limit the application of many enamels to castings or round, elliptical or flat surfaces such as can be dealt with in lathes and planing machines.

When the skin of the casting is not removed efficiently and an unsuitable process of enamelling is used, it will be found that before the enamel has become hot enough to fuse completely, it will, in the language of the enameller, commence to "bleb." That is to say, some action takes place which results in the evolution of a considerable volume of gas, which causes the enamel to blister; and when this happens, it is then impossible to obtain a perfect coat for further heating. The blebbing appears to be due to a reaction between the metal and the enamel, but may be due in part also to the liberation of the gases dissolved in the métal. Even when the skin of a casting has been removed efficiently, and a suitable enamel has fused to a perfectly level coat, a further unnecessary rise in the temperature will cause "blebbing" to occur, and in general it may be said of any enamel upon cast iron, that between the temperature at which the enamel will fuse quietly and the temperature at which "blebbing" will commence, there is a somewhat narrow range, and other things being equal, the best enamel is that which has the widest range between these points, because in practice the temperature owing to working conditions cannot be kept within very narrow limits, and blebbing means waste and commercial loss.

From their experience in the enamelling and tinning of castings on the natural skin, manufacturers are of opinion that metallurgists have much to learn as to the constitution of the skin of castings.

In an attempt to throw some light upon the subject in its bearing on enamelling and tinning, I made some preliminary experiments, to test the possibility of producing some considerable alteration in the constitution of the skin of castings. Various facing materials, including steatite, lime and magnesia dust, were tried, and castings were run in red hot loam moulds faced with these various materials in an atmosphere of coal-gas so as to exclude free and combined oxygen, but so far the results have been entirely negative. There has been no observable difference in the appearance of the castings, or in their behavior in enamelling and tinning.

Prparation of an enamel.—In compounding an enamel for any particular purpose, the enameller usually makes no attempt to produce silicates of any definite chemical constitution, but follows such empirical rules as his experience may have taught him to accomplish his objects, and probably he is right. The preparation of an enamel must not only have regard to the physical properties required in the finished enamelled article, but must also conform to the qualities

necessary in the enamel in the act of fusing upon the article; some of which are: Temperature at which the enamel fuses; range between the fusing point and the temperature at which "blebbing" will take place; viscosity; surface tension.

The fusing point of an enamel is usually controlled by the proportion between the alkaline bases and the silica; by the use of borax, boric acid, or in some cases by lead compounds, but an undue proportion of alkaline bases or borax tends to produce softness and solubility of the enamel in aqueous solutions.

The difficulty as to "blebbing" has been alluded to and must be lessened by experience and skill in producing the enamel.

As regards viscosity in the enamel in the fused state, a high degree of viscosity is especially desirable when it is necessary to prevent the fused enamel running down any vertical surfaces of the castings; on horizontal surfaces it is of course not so important. Silicate of alumina is one of the components which is frequently employed for this purpose, but it has also a tendency to raise the melting point, which must be re-adjusted. Barium silicate is sometimes used when it is desired to reduce viscosity, but this has a tendency to lower the melting point of the enamel.

A high degree of surface tension is generally desirable in the enamel in a fused state, as it is the play of this force at the moment of fusing which stretches the enamel to a level smooth surface. It is possible, however, to have the surface tension too high. At the moment of fusing, the force of adhesion between the enamel and the under coat, as the case may be, should be considerable; that is, the fused enamel should "wet" the surface. There must be a proper balance between the forces of adhesion and surface tension. If the adhesion is not sufficient, the surface tension will cause the melted enamel to run up into isolated globules.

In the making of an enamel, the materials, in a fine state of division and well mixed, are fritted or melted in crucibles or reverberatory furnaces. The temperature of the furnace and the length of time in the furnace are important. Possibly the silica and the various bases arrange themselves differently at different temperatures; at all events the furnacing of the enamel materials may produce considerable differences in the physical properties of the enamel. The adjustment of the co-efficient of expansion for heat does not usually cause much trouble, as the enameller has his well-known formula and method which generally turns out right. But when something goes wrong, or when an enamel is required to comply with certain new conditions which may have been successfully met, except that the expansion co-efficient is too high or too low, it becomes necessary to correct the expansion co-efficient. There are several ways known to enamellers of doing this, but it is the case with most of us, that we cannot express even in approximate figures what will be the result of any given correction we may make. We do not even try to measure in figures the co-efficient of expansion; all we know is that we must adjust it to that of cast iron, viz., to 0.0000112 per degree Centigrade, as measured between 0° and 100° C.; and we do the adjusting by trial and error. Perhaps in the case of a saucepan, it would be better practice to make the expansion co-efficient of the enamel rather higher than that of cast iron, since the enamel in contact with a fluid, would rarely rise quite so high in temperature as the outside of the vessel whilst in contact with the source of heat. The subsequent cooling is a more gradual and equable process, and not likely to set up sudden local strains.

Grinding the Enamel.—Enamels are applied to the metals in various ways, wet or dry; but in all cases it is necessary to reduce the enamel to a ground or powdered state, to permit of distribution in an even layer. The degree of fineness to which an enamel is ground or powdered is important. In the wet process, the enamel must be fine enough to remain in suspension in water for some time, but grinding too finely appears to affect the expansion co-efficient for reasons which are not easy to see, and the result is what is known as "crazing," i. e., very fine cracks in the enamelled surface. Ideal grinding generally consists in obtaining all the particles of enamel of the same size; but in some ways of applying the enamel, it is an advantage to have a mixture of fine and relatively coarse particles. Grinding in the wet way is accomplished in mills lined with French burrs, with runners of the same material, or in horizontally rotating cylinders lined with hard porcelain and partially filled with glass balls or flint stones. With the mills, the large surface of the runners moving uniformly over a large number of particles of enamel tends to reduce them all uniformly in size, and is the best system where the enamel is required to be of any given degree of fineness, except the extremely fine; although this can be attained by prolonging the time of grinding. The cylinders, on the other hand, are best when the enamel is to be ground extremely fine. The actual surface contact between the glass balls or flints is so small that the pressure per unit of area is great and some of the enamel is at once reduced to extreme fineness, whilst the remainder is comparatively coarse. For fine grinding the cylinders are not only better but rather quicker, and the materials are not exposed to contamination from dirt.

For reducing enamel to powder in the dry way, edge runners of granite on a granite base are used, sometimes an ordinary French burr mill.

In all foregoing methods every care is taken to prevent contamination by metallic particles or organic matter, which gives rise to defects in enamels. In some of the coarser forms of enamelling where the specks and stains due to metallic particles do not matter, edge runners of cast iron or ordinary stamps are used.

Application and Fusing.—When the enamel is used in suspension in water as a cream, it is ground finely

with a small percentage of china clay, magnesium sulphate, or other agents to increase the specific gravity and viscosity of the cream, so as to keep the enamel in suspension longer, and to facilitate the operation of flowing the cream over the surface of the article to be enamelled in a uniform layer of the desired thickness. After drying the enamel is ready for firing.

When the enamel is applied in the dry state it is not so finely powdered, and is distributed with the aid of a sieve, or in other ways, over a surface coated with gum, or direct upon the red hot surface of the cast iron, either the bare metal or coated with a first coat. In the latter case the metal carries enough heat to fuse the enamel immediately it falls upon the surface, if the operations are carried out quickly, and the enamel has a low enough fusing point. It may or may not be necessary to return the article to the muffle to produce a perfectly fused surface. In some cases a combination of the wet and dry methods is used; and two or three coatings may be given of the same or different enamels by successive firings. When several coats are used, it is nearly always an advantage for the lower coats to be less fusible than the upper. When different enamels are superimposed, it is of course necessary that their co-efficients of expansion agree; and that they are otherwise a suitable combination.

In the firing of an enamelled article in a muffle, the enamels are partly protected against the furnace gases, but not altogether. Some enamels will not stand the action of the gases for long without deteriorating, and must be removed soon after complete fusing. With castings of uniform thickness, which rise in temperature equally all over the surface, this presents no difficulty, but in the case of a casting, especially a large casting which has thin parts and thick heavy parts, the heating is irregular, and the enamel upon the thin places is liable to be fused and spoilt before the enamel on the thick parts is melted. Such work is difficult and requires great experience.

When an enamelled surface is produced by two coats, the lower of which is a boro-silicate or other mass of comparatively high fusing point, and the upper a more fusible glaze, some considerable advantages are gained, one of which is that an enamel which could not be used direct upon the metal surface, can be used as the upper coat. Another advantage is that when necessary the enamel may remain longer in the muffle without damage; this is important with irregular and heavy castings. This method, however, requires accurate adjustment of the enamels, and special care in the operations, otherwise the lower layer may remain porous, so that liquids will rapidly penetrate by capillary action, as soon as there is the slightest flaw in the upper surface. The lower layer must at least soften sufficiently to form a solid mass, or the upper layer must penetrate the lower and fill up all porosity.

White Enamels.—Colored enamels are produced much in the same ways that are adopted with glass and pottery, and scarcely require comment, except where the enamel is a more or less opaque or translucent white. There are several ways in use for producing the effect of a white surface: (1) By mixing with a transparent enamel some opaque white substance which does not enter into combination with the enamel, but remains as a mechanical mixture. Oxide of tin is an example. A specially pure and finely divided oxide is prepared for enamelling, and is introduced at the latest possible stage, so that the mixture of enamel and tin is heated as little as possible, otherwise the oxide of tin will enter into combination with the silica with a partial or total loss of opacity. In the application by the wet method the oxide of tin is often added to the enamel frit in the mill, and the two are merely ground together. Bone ash is probably another example. (2) Cryolite, or other fluorine compounds, with some enamels will produce a translucent white. Apparently the effect in these cases is due to the production of minute crystals having a different refractive index to the rest of the enamel. Overheating causes a loss of opacity which partially returns on cooling. (3) A white color may be produced by coating a transparent or opalescent enamel upon a white ground layer of a boro-silicate, or other mass of a comparatively high fusing point. The lower layer does not fuse completely, but softens sufficiently to adhere to the surface of the metal, and supplies an opaque white ground, whilst the upper layer of enamel furnishes the smooth and glossy surface. (4) The effect of a white color can also be given by the production of excessively fine air-bells in a transparent enamel. In this case considerable viscosity in the enamel is necessary, otherwise the air-bells coalesce with a loss of opacity.

Pinholes, a common trouble of enamellers, are "solutions of continuity" of the surface of the enamels in the shape of small round holes. They are due to several causes (1) presence of fine particles of organic matter which are allowed to get into the enamel for the upper coat. Splinters of wood ground up with the enamel are a common source of trouble. These minute particles of organic matt " become decomposed with the heat of the muffle and form small bells of gas, which either remains as such, or burst and form holes in the enamel which frequently will not close up. (2) Microscopic fissures or holes in the casting, the air from which expands by heat and forms air bells in the enamel. (3) "Blacks," that is, slag or scum in the skin of the castings which produce bells of gas by re-action with the enamel. (4) Imperfections in the first coat of enamel which expose the metal to the attack of the upper coat of enamel. (5) Particles of foreign matter or spots due to imperfect preparation in the first coat of enamel where the force of adhesion is less than the rest of the surface; these result in spots which the upper layer of enamel will not cover.

Principles in Application of Enamels.—There are at least four well defined different principles in the application of enamels to cast iron.

1. That embodied in Clark's patent, viz., an under coat of considerable thickness, with a relatively high fusing point; this is applied in the wet way, dried and fired, and an upper coat of enamel of a lower fusing point added.

2. A very thin special under coat is applied in the wet way, dried and burnt right into the surface of the iron. There is then scarcely any visible coat, but the surface of the iron is affected so that the propensity to "bleb" is retarded, and an ordinary fusible upper coat can be added.

3. A moderately fusible enamel is applied in the wet way direct upon the surface of the iron, dried and fused.

4. One or more coats of very fusible enamel are applied as a dry powder direct upon the red hot surface of the metal.

Methods 1, 2 and 4, can be used upon the natural skin of the casting or the machined surface. Method 3 as a rule can only be applied upon a machined surface, although with a few enamels it is impossible to coat upon the natural skin. It is not a matter of indifference which way any enamel may be applied.

It has been recommended to submit the casting to the Bower-Barff process as a preliminary to enamelling. In my own experience I have not found any special advantage in this, whilst the extra cost has been a serious commercial handicap.

To satisfy many of the conditions laid down in this paper, either singly or together, is not so difficult, but to satisfy all of them at the same time is difficult, and sometimes impossible. It is to be hoped that enamellers will abandon their habit of attacking problems single-handed, and will combine amongst themselves, and with trained chemists, seek to place upon a different footing an industry which if it is destined to remain a minor one, is at least of absorbing interest.

In conclusion, I have to express my acknowledgments to Sir William Kenrick, Sir George Kenrick, and Mr. C. F. Clark, for some of the information incorporated in this paper.

IMPORTANT ADVANCE IN TUNGSTEN METALLURGY.

The Research Laboratory, at Schenectady, of the General Electric Company has succeeded in producing pure tungsten which is so ductile that it has been drawn into the finest wire, and which possess extraordinary tensile strength. Dr. W. R. Whitney, in charge of the laboratory, has conducted over a long period a systematic research into the metallurgy of tungsten, and for this purpose has developed a most interesting form of electric furnace. The outcome of this work, as noted above, appears to be of the highest importance with respect to the improvement of the tungsten lamp, as the increase in ductility and tensile strength should greatly lessen the fragility of the filament, which defect has, in no small measure, retarded the introduction of the new lamp.

BINDER-MATERIALS MADE FROM SULPHITE-PULP-WASTE.*

By ROBERT SCHORR.

This subject has received a great deal of study and practical attention in Europe for many years, and more recently also in this country. While even a gigantic commercial development in that direction would not wholly solve the serious problem of stream pollution by waste liquors resulting from the manufacture of paper-pulp by the sulphite process, it would reduce the nuisance in many localities where the material could be marketed in competition with coal-tar products, asphaltum or other binders. A glance over the figures as presented in Water Supply Paper No. 226 of the U. S. Geological Survey and in Circular No. 120 of the Forest Service, must impress one with the wide scope of the work, which, in spite of most exhaustive research, has established no important results or remedies.

About half of all wood-pulp is made in the United States by the sulphite process. In 1906 almost 2,000,000 cords of wood were consumed by it, and yielded over 1,140,000 tons of "dry" pulp. The amount of solid material discharged with the waste liquor per ton of pulp produced varies from 2,200 to 2,700 lb. Assuming an average of 2,500 lb., this represents a total of over 1,350,000 tons of solids for 1906.

Every ton of dry pulp requires about 2,285 gal. of acid-liquor, and the same amount of water for each of the two washes. The acid application and the first water-wash constitute, as a rule, the waste liquor discharged by the mill. Consequently we had, in 1906, about $1{,}140{,}000 \times 2 \times 2{,}285$ equal to over 5,200,000,000 gal. with over 1,350,000 tons of solids contaminating our waters. These figures are approximate only, as the degree of dilution varies with different plants and equipments. The relation between pulp output and solid waste, however, is more definite. This waste contains 70 to 80 per cent wood material (lignocellulose), 8 to 19 per cent inorganic matter ($CaSO_4$ and $MgSO_4$) and 8 to 11 per cent sulphur. This will give a general idea of its character and, as far as concerns our theme, it is not necessary to discuss the complex chemical nature of the organic portion. There is much valuable literature on this subject, foremost being the *Journ. f. prakt. Chem.*, Carl Hoffman's book on Paper Manufacture and the *Papier-Zeitung*.

UTILIZATION OF WASTE.

Numerous processes for utilizing this immense waste have been patented, and, it appears to me, the condensation into pulp-tar or pitch by simple evaporation seems most promising at the present time in a number of states. This statement is made with the knowledge that some of the earlier installations for this purpose have not proved a financial success, but since that time conditions have improved with the progress in the design of evaporators and the in-

*From the Engineering and Mining Journal.

creased demand for binder. The cost of adhesives is, in many localities where pulp factories exist, excessively high, and this fact should insure a commercial success in spite of the rather high expense of manufacturing pulp-pitch.

It can be used as a substitute for glues, also as a binding agent for coal, coke breeze, flue dust, ore fines, sand and the like. Although this evaporated extract has been used for these purposes for several years, the most rapid progress was made in that direction during the last year. A number of large German iron works have again abandoned the practice of sintering their fines, and it is reported that they are briquetting them and flue dust with sulphite-pulp-pitch as a binder. Cores for casting are extensively made with it in this country and in Europe.

COMMERCIAL ASPECTS OF PULP-PITCH.

For the process of evaporating the waste liquor, its degree of concentration is obviously of vital commercial importance, and, to avoid undue dilution, the acid-wash should be kept separate from the water-washes and other drains wherever practicable. The operation is costly even when handling comparatively strong solutions, as large quantities of water have to be expelled to obtain a limited amount of pulp-pitch or pulp-tar. However, in investigating the commercial end of such undertakings the superior adhesive qualities of these materials have to be borne in mind.

The melting point of pulp-pitch is high, and it can be shipped in bulk as it does not soften at ordinary temperatures. The briquets I have made with it fulfill all physical requirements. They ignite readily and as coking sets in they retain their shape, not disintegrating until completely consumed. The briquets are strong but not entirely waterproof. The pulp-pitch does not increase smoke or odor, and, as nearly all of it is combustible, it adds but little to the ash content. Its influence upon the heating value of the fuel is negligible.

The great adhesive power it possesses makes it an ideal binder for mineral substances, both in connection with metallurgical undertakings and also for the manufacture of artificial stone masses. In many cases, however, waterproofing will be necessary.

The installation for the evaporation of waste-liquor is rather expensive, and before designing such a plant it is important to secure an average sample.

Pulp-pitch sells in Germany for 40 marks, about $10, per ton and the manufacturing cost is said to be in the neighborhood of 25 marks. The evaporating has to be done at a low temperature to avoid charring and excessive losses. In most pulp mills exhaust steam is available for this purpose, or live steam could be cheaply generated by using the large amount of refuse from the barkers and the ¼-in. rejects as boiler fuel. In the latter case low-pressure steam could be made and an exhaust-steam turbine could be operated in conjunction with the evaporators.

THE MANUFACTURE OF BALATA BELTING IN THE UNITED STATES.

A combination of German and American capital has been brought together for the building of a great Balata belting factory in the United States. Though hundreds of thousands of feet of balata belting art in service for transmission purposes in the United States at the present time, not one foot of this kind of belting is manufactured in America. All of it is put together in factories in Germany or England and imported here. The announcement, therefore, that a syndicate has been formed to introduce this new manufacturing interest into the United States will be of considerable interest to manufacturers generally and especially to those who at the present time are using large quantities of this kind of belting.

The corporation behind the new enterprise is known as the Victor-Balata & Textile Belting Co. The American interests represented in the new company are Charles E. Aaron and John R. Stein, president and treasurer, respectively of the New York Leather Belting Company of New York City. The German interests are represented in the new company by William Vollrath, Albert Vollrath and Edwin Vollrath of the firm of C. Vollrath & Sohn of Blankenburgh, Germany. The latter company is the largest of the textile belting manufacturers of the European Continent and the former company were pioneers in first introducing Balata belting upon the American market. The officers of the new combine are Charles E. Aaron of New York, President, Edwin Vollrath of Blankenburgh, Germany, secretary and John R. Stein, New York, treasurer.

The building of the new plant will entail an expenditure of half a million dollars in buildings and equipment and will be located at Easton, Pa. Work on the first two buildings of the new plant will be begun immediately.

The factory site covers nine acres of ground and is located to the westward of Easton in a suburb known as Palmer. The city of Easton, however, will extend its limits to take the new plant within its borders to give it the benefit of fire-protection. A 1,000-foot siding is being built at the present time by the Lehigh Valley Railroad from its main tracks to the factory site to handle the freight.

Two buildings to be erected immediately include the main factory building 150 feet in length by 100 feet wide and an impregnation building 75 feet deep and 60 feet wide. Both buildings will be constructed of concrete and structural steel to render them absolutely fireproof. Another interesting feature connected with the new plant is that a complete miniature village will be erected on the site to house the workmen of the plant. All the dwellings will be of concrete. A great weaving plant for the weaving of cotton duck will be an added feature as soon as machinery is built.

The advent of a plant for the manufacture of bala-

ta belting to the United States brings out many interesting features relative to the manufacture of this type of belting. One of the most interesting is the extreme secrecy which has always guarded the various plants where this belt has been manufactured abroad.

Balata belting is composed of cotton duck and a substance known as balata gum, a South American product. Few patents have ever been taken out on the manufacture of this belt or the machinery and processes used.

The Vollrath interests in Geermany maintain one of the largest balata belting factories in the world. All the machinery for the operation of their plant has been constructed behind closed doors in their own foundries. Workmen, who know the secrets, live and die in the employ of the concern.

Specially woven cotton duck is also made in this plant abroad. The looms upon which the duck is woven are built by the makers of the belt and a heavier and more evenly stretched duck is produced from these looms than from any other looms in Germany. The process of weaving is also regarded as secret. No visitors under any pretext are ever allowed in the Vollrath plant.

The same precautions will be observed in the new plant at Easton. The machinery complete for the manufacture of the belt, as well as for the weaving of the cotton duck itself, are being constructed abroad and will be shipped to America and installed under the personal supervision of Mr. William Vollrath, senior member of the German firm. His son, Mr. Edwin Vollrath, as soon as the factory is ready for operation will make his home permanently in the United States and will act as executive head of the factory, having under him workmen skilled in the manufacture of balata belting.

Until less than ten years ago no one in the United States knew what balata belting was. For thirty or forty years it has been a staple belt on the European market and was used largely.

Small quantities of balata belting were imported here by the New York Leather Belting Co. about a decade ago. It was tried out for a time with little success. Then certain changes were made in the method of its manufacture which made it successful on American machinery. For the past five years approximately a million dollars' worth of this type of belt has been imported here annually. Balata belting will withstand dampness and changes of climate and is claimed to be a hardier belt than rubber belting. The success balata belting has met in America has brought three or four European manufacturers of balata belting to America. All of them are importing up to this time. The heavy import duties and the delay in filling special orders, etc., have in large degree limited the sale of the belt.

It seems probable that the building of this big plant for the manufacture of balata belting will mean a large increase in its use and a diminution in its price.

The Victor-Balata & Textile Belting Co. also contemplates the building of several other factories on its site for the manufacture of other textile belts, similar to textile belts manufactured in the United States. A novel feature in this is the fact that the company will not only make its own belts but also weave its own duck. None of the textile belting manufacturers are at the present time weaving their own duck, though many of them have it made in textile mills where it is woven under their own specifications.

The new plant expects to begin installing its machinery in September and be in full operation late in October. When the chain of buildings for the new plant are completed the plant will be one of the largest textile belting factories in the world.

The U. S. Civil Service Commission, Washington, D. C., will hold an examination on July 27, 1910, to secure eligibles from which to make certifications to fill vacancies as indicated below in the positions of assistant qualified in dairy chemistry and dairy bacteriology in the Bureau of Animal Industry, Department of Agriculture, and vacancies requiring similar qualifications as they may occur, unless it shall be decided in the interest of the service to fill any or all of the vacancies by reinstatement, transfer or promotion: Two qualified in dairy chemistry, at from $900 to $1,200 per annum, for service at Washington, D. C. One qualified in dairy chemistry, at from $1,400 to $1,800 per annum, for service at Washington, D. C. One qualified in dairy bacteriology, at from $1,400 to $1,800 per annum, for service at Washington, D. C. One qualified in dairy chemistry, at from $1,400 to $1,800 per annum, for service at Columbia, Mo. One qualified in dairy bacteriology, at from $900 to $1,200 per annum, for service at Madison, Wis. The department states that the vacancy at Madison, assistant in dairy bacteriology, at from $900 to $1,200 per annum, may be filled by either men or women, but all the other vacancies mentioned must, in the interests of the service, be filled by men only.

The yearly world's production of emery is about 35,000 tons, of which Greece produces 9,000, from the island of Naxos. The right of mining the emery is enjoyed by the inhabitants of certain districts, the government transporting the product to Syra, where it is sold for about $20 per ton. The Naxos emery contains over 60 per cent of corundum. Magnesite is of great industrial value on account of its resistance to heat, which renders it suitable for lining furnaces and for firebricks. It is also used for making cement. Magnesite is found principally in the island of Euboea, in veins 15 to 25 meters in thickness, and several kilometers in length. It is exported in a crude state at $3.70 per ton; calcined, at $13 per ton; dead burned, at $14 per ton; in brick, at about $14.50. There is great demand for the Greek magnesite at present, and the possible output has been ordered in advance for some time to come.

THE PLANT.

AMMONIA SODA; ITS PRESENT STATE AND ITS FUTURE.*

By ALBERT COLSON.†

In the following lines, I propose to explain the scientific basis of the present state of the manufacture of ammonia soda, and to point out, finally, the possibility of modifying this process.

ADVANTAGES OF THE PROCESS.

The output of ammonia soda amounts at present to two million tons per annum. The French production, which reaches almost 300,000 tons, is smaller than that of England, and also of Germany. This is due to the large number and the small output of the French salt mines, which submit to the law of the salt mines rather than combine for mutual deference.

The ammonia process plays, today, the most important part in the soda industry, and of its alkaline derivatives. At the first sight its dominating position appears to be a legitimate one, and it would seem that it is destined to retain this for a long time to come, for the competition of the electrical processes is not likely, at any rate not in the near future, to reverse the position. These views find their support in the following argumentation, which, however, should be accepted only in a general way.

The process comprises the following operations:

(1) The manufacture of caustic lime, $CaCO_3 = CaO + CO_2$.

(2) The carbonatation of the ammoniacal brine. $2(NaCl + NH_3 + H_2O + CO_2) = 2(CO_3NaH + NH_4Cl)$.

(3) The calcination of Bicarbonate.

$$2CO_3NaH = CO_3Na_2 + H_2O + CO_2.$$

(4) The regeneration of the ammonia.

$$2NH_4Cl + CaO = CaCl_2 + H_2O + 2NH_3.$$

The total cycle of the operations is the resultant, i. e., the algebraical sum, of all the foregoing reactions, and it can be summed up in the following equation:

$$CaCO_3 + 2NaCl = CO_3Na_2 + CaCl_2 - 5200 \text{ cal.}$$
(solid) (dissolved) (solid) (dissolved)

This final equation expresses the following facts: (1) The ammonia plays only an intermediary part, in that it induces a double decomposition between the salt and the calcium carbonate. (2) This double decomposition takes place almost without evolution of heat, so that it is not necessary to have recourse to energetic reactions to produce it.

It goes of course, without saying, that in practice it is not sufficient to supply 5200 calories in order to effect the final reaction. In the case at present under our consideration, it is necessary, as will be shown below, to decompose the limestone by heat. This decomposition requires 44,500 calories. If this decomposition be effected in a separate operation, then, theoretically, the cycle of successive reactions can take place, and whilst yielding sodium carbonate, leave an excess of 39,300 calories. For this reason then, speaking theoretically, it appears to me necessary to decompose the limestone in a special operation and to exclude this operation from the cycle of reactions which furnish soda. It is well known that the determining factor of the reaction is not the quantity of heat which is set free.*

In my opinion, it is the height of the temperature, and not the quantity of the heat, resulting in the course of any reaction, which plays the predominant part. To give an example, I would say that in the production of aluminum by heat, the aluminum decomposes the chromium oxide, because the compound alumina sets free, not a larger quantity of heat, but a higher temperature, than does the compound chromic oxide; this conception accords with the relative stabilities of these compounds, i. e., their resistance to the action of high temperatures. This condition is, however, subordinate to another condition, which I will explain, as it is by no means familiar to chemists; namely the temperature of the reaction: If aluminum and copper are heated in a saturated petroleum ether solution of sulphur, the copper is attacked and not the aluminum, in spite of the greater heat and higher temperature which the formation of aluminum sulphide would develop; evidently the copper combines

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†*Professor at the Ecole Polytechnique, Paris.*

*Note.—According to the laws of thermo-dynamics, the non-compensated heat determines the possibility for chemical reaction to take place. This does not appear to be in agreement with the following experience:

The decomposition of methyl salicylate by lime proceeds, as is well known, according to the following equation:

$$(OH)C_6H_4CO_2CH_3 + CaO = C_6H_5OCH_3 + CaCO_3$$

If the quantity of heat evolved, either the total or the compensated heat, is really the cause of the reaction, it would appear that the heat of formation of the carbonate, CO_3Ca, which is enormous, should have a great influence on the reaction. My experiments, however, prove that this is not so, for under the same conditions, the reaction expressed by the following equation:

$$(OH)C_6H_4CO_2CH_3 - C_6H_5OCH_3 + CO_2$$

precedes the complementary formation of the carbonate that is to say, the reaction, $CaO + CO_2 = CaCO_3$ is in no way connected with it.

with the sulphur at low temperatures, and not the aluminum.† The facts speak for themselves.

If we consider the manufacture of soda in the light of these theoretical considerations, we arrive at the following conclusions:

The reaction requiring the highest temperature is the decomposition of the limestone, and none of the reactions taking place in solution, and really characteristic of the ammonia process, attains to this temperature. Hence it is necessary to burn coal to obtain the above decomposition, whereas all the other operations take place without such aid.

OPERATIONS.

I now pass on to the consideration of the four fundamental operations, corresponding to the above given four chemical operations. Every one of them implies a special apparatus and presents special difficulties. To the brothers Solvay and to the engineer Hanrez belong the honor of having been the first who designed and erected apparatus permitting a remunerative yield. It would, however, be a mistake to believe that the apparatus used by the Solvay Company are indispensable for the manufacture, or even that they are superior to other types of apparatus. Hence I omit the description of apparatus, which may be of various types.

1. *Lime Kilns.*—The kilns used for the decomposition of limestone are heated either by gas, or by coke, or coal mixed with the limestone. The kilns must be of closed type, so that the carbonic acid, resulting from the decomposition of the limestone, can be drawn off, and pumped into the carbonating towers. It would seem, therefore, a very simple device to apply to a continuous lime-kiln a pump which draws off the gas, and presses it into the towers, and apparently one could not see why there should be any difficulty in so simple an operation. As a matter of fact, I could cite the case of an ammonia soda works which had to be closed, because the pumps were rapidly destroyed by the fine dust and the gas, and could not perform the work expected of them.

Moreover, a simple change in the duty of the pumps may alter the routine of the manufacture to such an extent, as to nonplus the most experienced manager. I myself have had to deal with such difficulties, and it was not without trouble that I was able to overcome them.

2. *Carbonatation.*—The preparation of the ammoniacal lyes, though requiring careful attention, offers no difficulty. On the contrary the brothers Solvay had so many obstacles to overcome in the carbonatation that for a long time afterward it was held that their apparatus was exclusively suitable for the manufacture of soda. As a matter of fact, this apparatus represents a perfect arrangement. It consists of a column, divided into compartments, the bottoms of which are perforated with holes.

The brine runs through the column from top to bottom, whilst the carbonic acid gas passes, countercurrent fashion, from the bottom to the top. Thus the most highly carbonated lyes come in contact with those gases which are the richest in carbonic acid. Hence, the theoretical conditions, for a methodical exhaustion of the gases, are perfectly realized.

Nevertheless, intermittently working apparatus, simpler in design, and more easy to manage, furnish almost identical results, provided they are properly controlled. Such in particular are the apparatus which Roland and Schloesing used at Puteaux in 1855.

I shall detail below the principal conditions for a good carbonatation, which is an essential condition for a good yield.

It is, however, not sufficient to obtain an abundant precipitate, for it is also necessary that the soda grains be large and colorless. Each factory has its own secret methods for obtaining this result, whilst there is a general similarity between them. These details, however insignificant, apparently are very important in practice. If the grains are discolored, the soda is difficult to sell, and if the deposit is muddy, it clogs the filters or the hydro-extractors. The separation and the washing of the bi-carbonate then becomes difficult, the yield decreases, and the quality of the product is lower.

3. *Calcination.*—The bi-carbonate, after separation and washing is subjected to calcination. The facility with which this salt is decomposed appears to point to ready desiccation. On the contrary, this operation represents one of the rocks on which a manufacturer of ammonia may founder. On the one hand, it is convenient to work with a closed vessel, so as to recover the carbonic acid and the ammoniacal vapors. On the other hand, it should be made to revolve in furnaces, for the bi-carbonate is always moist. Besides, its decomposition leads to the evolution of water, so that the material agglomerates in more or less large lumps. Under the influence of the heat, the outer crust of these lumps become hard, and forms a layer which protects, by reason of its bad conductivity, the innermost parts from the influence of heat. Hence, the drying out takes place with difficulty, even at very high temperature. Here also, to overcome the difficulties, a number of different and well-known apparatus are in use.

4. *Regeneration.*—The regeneration of ammonia offers a number of problems. The regeneration is carried out in columns, analagous to those which are used for the rectification of alcohol; but the dimensions are much larger, for the columns must be capable of recovering ammonia from 15 to 20 cubic meters of mother liquors, per hour. In this operation leakages, the production of foam, and the running empty of the plates, must be avoided. Above all, it is necessary to keep the lime in continuous contact with the ammonium chloride in the mother liquors. For this purpose

†Even in the case of a chemical equilibrium where the heat of formation L is related to the pressure P, and the temperature T as expressed by a formula analogous to that of Clapeyron, the formula only holds good above that temperature at which the equilibrium is established.

the column is fitted, in each of its compartments, with agitators. The milk of lime, in regulated quantities, is introduced by means of a pump which forces the liquor into the column at the desired height, to act on the chloride. At present, it has become possible to replace the milk of lime by caustic lime. In any case, the working of the columns, like that of every other apparatus, must be controlled by continuous sampling, so as to leave nothing to chance. The stoppage of this apparatus would lead to the stoppage of the whole factory; hence, two columns must be provided, although it entails a somewhat heavy expense.

5. *Losses of Ammonia.*—An important operation following in the wake of the working of the carbonators and the calciners of the bi-carbonate, is the recovery of the ammonia. For, as shown above, the ammonia acts as an intermediary, which must do its work indefinitely; in fact the realization of this condition is the essence of the whole process. The loss must not exceed 2.5 kilos. per ton of dry carbonate, and even this means already an expense of 2s. 1d. It is difficult to carry the recovery even to this point, and the best thought-out means do not always lead to success. I have seen Glover towers fed with sulphuric acid which did not yield good results.

Can one therefore maintain that theory differs from practice? In reality it was not the chemistry which was at fault, but the application which was faulty. Suspecting that the free section left in these Glovers for the passage of the gas was too small, and hence that in order to obtain the requisite output, it had been necessary to provide a more active circulation, which no longer permitted the thorough contact between the liquid and the gas, I enlarged the sections of the recuperating towers. In consequence of the diminished rapidity of circulation thus produced, the absorption of the ammonia then took place. Moreover, the employment of apparatus for a methodical extraction furnished me with excellent results, which have been constantly confirmed since 1894; thus, water, in a vesicular state, saturated with carbonic acid has replaced, with advantage, the sulphuric acid.

PRECIPITATION.

Having reviewed the operations, and pointed out the difficulties they offer, I will revert to the fundamental equation which determines the yield:

$$NaCl+NH_3+H_2O+CO_2 = CO_3NaH+NH_4Cl.$$

This reaction proceeds by itself, i. e., takes place without any extraneous intervention. But in practice the precipitation of the soda must be complete and rapid. Such precipitation is limited by the solubility of the bi-carbonate in the generating liquid and even by the possibility of ammonium chloride being deposited. It is clear that if these two salts fall out simultaneously, they will react upon each other during the calcination and thus regenerate sodium chloride in equivalent quantities. In practice it is necessary to work under conditions which are most favorable to the precipitation; moreover the latter must be stimulated, for the output of any given apparatus depends evidently upon the duration of the carbonatation. As long as the liquid is alkaline, precipitation does not take place. In fact, if we bring bi-carbonate into contact with the ammonia, there is formed the product CO_3NaNH_4, that is to say, a mixture of the neutral carbonates of soda and ammonia, both of which are soluble.

I have carried out some experiments with a view to determining to what extent ammonia interferes with the solubility of pure sodium bi-carbonate. For this purpose I dissolved sodium bi-carbonate in water heated to from 40°—50° C. I took equal volumes of the hot, clear solution, added ammonia gas, and allowed to cool, side by side with a blank test in which there was no ammonia. The alkalimetrical determinations of the crystals which were deposited from the solutions placed in melting ice, yielded the following results: Blank test, 12.5 c.c.; Ammoniacal solution titrating 5 c.c., 8 c.c.; difference, 4.5 c.c.

When the ammoniacal solution contains as much free ammonia as corresponds to 10 c.c. of the standard solution, the deposition of the carbonate ceases, but reappears at once, when the carbonic acid gas is brought into contact with it; it is, therefore, indispensable to carry out rapidly the saturation of the ammonia with the carbonic acid. Without doubt, the employment of gas rich in carbonic acid is very favorable for this purpose. Besides, it offers the advantage of improving the yield, for, according to the measurements of Dibbits, the tensions of carbonic acid gas in saturated solutions of bi-carbonate are as follows: 120 millimeters at 15° C.; 212 mm. at 30° C.; and 356 mm. at 40° C.

If then, one operates at 25° S. with gas of which the tension, due to carbonic acid, is only 120 millimeters, that is to say with gas containing only 15 to 16 per cent. of carbonic acid by volume, the precipitation of bi-carbonate would no longer take place.

These theoretical predictions agree with the following results, which I have accidently observed in practice. An apparatus capable of yielding 4800 kilos. of carbonate in 8 hours with the aid of a gas containing 42 per cent. of carbonic acid, all other conditions being equal, has yielded the following results: (a) 2000 kilos. of carbonate in 15 hours with gas containing 23 per cent. of carbon dioxide. (b) 3200 kilos. of carbonate in 11 hours with gas containing 32 per cent. of carbon dioxide. (c) 4800 kilos. of carbonate in 8 hours with gas containing 42 per cent. of carbon dioxide. In all these three cases it was useless to prolong the carbonatation.

The Climax of the Solvay Process.—In a factory where the reaction is not only carefully studied, but actually so carried out in practice, there is nothing left but to perfect the mechanical means, so as to reduce, to a minimum, the manual labor, which even at present is not very considerable. This tendency is strongly marked everywhere, especially in those countries where the law regulates the hours of work. Already, manual labor has almost disappeared in the establish-

ments generating electrical energy. At Saint Denis, charging and discharging of the furnaces of the boilers takes place automatically. Naturally, as such installations can be used anywhere, they are also employed in the manufacture of soda.

As a mechanical arrangement is the more efficacious, the greater the quantity of material operated upon, the tendency is to increase the capacity of the apparatus and we observe already automatic lime kilns, each of which is capable of keeping up the yearly manufacture of 50,000 tons of soda. Installations of this size diminish the loss of heat through radiation, and permit the heating of the limestone in the form in which it is quarried, without it being required to break it, before charging into the kiln.

Assuming, somewhat arbitrarily, the cost of this kiln to be £40,000, and further assuming that it saves the wages of one hundred men, i. e., a sum of £5,000 to £6,000 per annum, and setting off against this the writing off, at 10 per cent. per annum, of the cost of the installation, the saving obtained under this heading amounts to £2,000 per annum, that is to say to 10d. per ton. This saving is, of course, not negligible, but it necessitates an outlay of capital which is not at the command of every manufacturer. Certainly, no one would erect a special factory, entailing an outlay of about £40,000, with the object of making a product which leads only to a profit of 10d. per ton.

Small works would find it more to their advantage to direct their efforts towards, and lay out their capital for a number of different details. I would recommend principally the enrichment of carbonic acid gas in the carbonating gases, the importance of which I have shown above.

Possibilities of a Transformation of the Process.—It would seem that the ammonia-soda industry has reached its zenith of perfection, and that it is only necessary to improve the details of this beautiful process. However, this is not altogether my opinion, and I wish to show now that there are other directions in which progress is possible.

Let me detail the cost-price of sodium carbonate. The resultant of the limiting reactions which give rise to this product may be summed up approximately by the following reaction: $3NaCl+CaCO_3=Na_2CO_3+CaCl_2+NaCl$, and the total expenses comprise: 1. The

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Residue.

cost of limestone. 2. The cost of salt, which must be used in great excess. 3. The cost of coal for heating the lime kilns. 4. The cost of coal for calcining furnaces. 5. The cost of coal necessary for the regeneration of the ammonia. 6. The cost of coal to produce steam for the engines. 7. The loss of ammonia. 8. Wages. 9. Depreciation. 10. Removal of the residues. Instead of endeavoring to obtain economies under each of these heads, i. e., to reduce the expense inherent to each of these items by a fraction which must necessarily be small, it would seem much better to effect the radical disappearance of some of these items.

To begin with, one is struck by the excessive, although indispensable, use of salt. If this product must be employed in its solid state, as is the case at the Solvay works in Belgium, and in the south of France, one surcharges the price of soda by at least 20 per cent. This saving alone would constitute an incontestable advantage. Now this is possible by replacing sodium chloride by nitrate of soda.

This residue of the manufacture will then consist of calcium and sodium nitrates, and after evaporation to dryness to waste heat, which is always to be had in large quantities in an ammonia-soda works, this residue retains the agricultural value of the nitrate from which it has been obtained.

But not even herein lies the true solution of the integral transformation of the ammonia soda process.

Before indicating such a radical change, I wish to show that the reaction with the aid of nitrate: $NaNO_3+NH_3+H_2O+CO_2=CO_3NaH+NO_3NH_4$ is at least as advantageous as is the reaction by means of sodium chloride: $NaCl+NH_3+H_2O+CO_2=CO_3NaH+NH_4Cl$. To begin with, the nitrate is more soluble than the chloride; hence, all other conditions being equal, the limit of the chemical change is put back because the ammoniacal solutions of nitrate will contain more soda. But even for the same amount of soda, the yield from a solution of nitrate should exceed that from a solution of sodium chloride. The decomposition of sodium nitrate by ammonium carbonate actually sets free 8,000 calories, whereas that of sodium chloride only sets free 7,100 calories. Now, in consequence of the rise of temperature, the deposited bicarbonate is redissolved by the mother liquors from which it has been separated, just like any solid salt redissolves on re-heating the saturated solution from which it has separated. These two reversible reactions are then comparable, with this difference, however, that the precipitation of the bicarbonate, being the result of a chemical change, depends upon the heat L which has been set free by the generating reaction, whereas for the solutions it is the heat of dilution which enters into the formula:

$$\text{Log } S = 500L\int \frac{dT}{T^2}$$

which correlates the solubility S to the temperature T.

At the same constant temperature, the solubility S, referring to the bi-carbonate obtained from sodium chloride, and the solubility S′ referring to the bi-carbonate from the nitrate, are then correlated by the formula:

$$\frac{\log S}{\log S'} = \frac{L}{L'}$$

which shows that if L is smaller than L′, S is also smaller than S′.

I wished to ascertain whether experiments would confirm this theoretical postulate.

I used a solution of nitrate containing as much sodium per litre of water as a saturated solution of sodium chloride would contain. Both solutions were treated with 87 grms. of ammonia gas per litre, and into both solutions carbon dioxide was passed under exactly the same conditions. In both cases the amount of precipitated bi-carbonate, as ascertained by titration, was approximately the same (sometimes higher and sometimes lower in the case of nitrate.) The reason why the experimental results do not agree well with the theoretical formula, is partly, the fact that the values L (=8000) and L, (=7100) relate to dilute solutions, whereas the actual precipitation takes place in concentrated solutions.

Be this as it may theoretically, it is certain that the yield of soda even increases when more concentrated solutions are employed. Furthermore, the substitution of the nitrate for the chloride furnishes a residue consisting of nitrates of calcium and of sodium, which has an agricultural value identical with that of the original nitrate. If, then, the residue is recovered by means of waste heat, the total cost of the sodium chloride would be saved.

In practice, the hygroscopicity of the calcium nitrate diminishes the value of the residue. Hence, the following procedure seems preferable: In the "nitrate process" the mother liquors, from which the bicarbonate has been precipitated, have a higher value than the ammonia and the sodium nitrate with which we started. Let us save the lime by evaporating these liquors, before they are passed into the columns. By utilizing the gases given off during evaporation, viz., ammonia and carbonic acid, and by extracting, partially at least, the ammonium nitrate dissolved in the mother liquors, there would be left a residue, extremely rich in nitrogen, and useful as a fertilizer, or, at least, as a source of nitric acid and ammonia.

Compared with the manufacture of soda with solid salt as carried out by Solvay at Salins and at Couillet, one would save per ton of carbonate: (1) 1600 kilograms of salt. (2) 1000 kilograms of limestone. (3) 120 to 150 kilograms of coal necessary for the transformation into quicklime. (4) The cost of heating required for liberating the combined ammonia. (5) The cost of installation of these columns. (6) The cost of disposal of the residues.

This is not simply introducing improvements in the essential operations, but the absolute suppression of these operations.

The ammonia process would then leave the circle within which it appears at present to be enclosed, and would start on a new career of development, which has some evident drawbacks, but exhibits also striking advantages. Among these advantages, the feature that the production of sodium carbonate would be transferred to the neighborhood of the sea ports, where the nitrate arrives, does not seem to be devoid of interest.

The cheapness of the sodium sulphate coming from powder mills and dynamite works, would also permit the substitution of this salt for the sodium chloride by concentrating the mother liquors from the bi-carbonate and producing a mixture of ammonium sulphate and hydrated sodium sulphate, which would constitute a fertilizer easy to handle.

In conclusion, I should like to point out that the chapter of chemical processes which leads to the production of soda is not yet closed.

A British corporation, The California Oil Fields, Ltd., operating in California, produced last year 4,378,464 bbls., against 3,563,679 in 1908, 3,242,942 in 1907, and 2,512,655 in 1906. The production for the entire State of California in the same years respectively was 58,000,000, 48,000,000, 40,000,000, and 32,500,000 bbls. The operating profits of the California oil Felds Co. in 1909 were $886,365, while dividends of 35 per cent were paid. The California company sold its product principally to the Standard Oil Company.

The contract for dynamite for the Panama Canal for the fiscal year 1911 has been let to the DuPont-De Nemours Powder Co. of Wilmington, Del., the amounts and prices being as follows:

45 per cent—8,540,000 lbs., at 11.7 cts.

60 per cent—5,187,000 lbs., at 12.7 cts.

The amounts quoted are estimated as the possible requirements for the fiscal year, but not more than 50 per cent of the estimated amount need be purchased. The first deliveries will be made in August.

According to a report of the British Consul-General upon the trade of Peru for the years 1908-09, the yield of coal during 1907 was 185,565 metric tons, a gain over 1906 of 105,596 tons, the greater portion being obtained from the Cerro de Pasco Mining Co.'s mines at Goyllarisquisga, and used almost exclusively for their smelting works. Anthracite is found in the Chimbote and Huaraz districts, in Otuzco, Huamachuco and elsewhere, and bituminous coal in Cajamarca, Ancachs, Ica, Arequipa, Puno and Moquegua.

A recent act of the State Legislature of Maryland provides for the establishment of five bureaus under the State Board of Health. These bureaus are to deal with communicable diseases, bacteriology, chemistry, sanitary engineering and vital statistics, respectively. The State Board of Health is authorized to appoint a chief and assistant chief for each of the bureaus, at salaries not less than $1,500 nor more than $2,400 for the chief and not less than $1,000 nor more than $1,800 for the assistant chiefs. The Board is also authorized to appoint draftsmen, inspectors and other employes.

THE MANUFACTURE OF IRON AND STEEL IN THE ELECTRIC FURNACE.*

By JOHN A SEEDE.†

Although Sir William Siemens used the electric furnace nearly thirty years ago, in substantially one of its present forms, and succeeded in melting some twenty pounds of steel, it was only recently that the electric furnace ceased to be a laboratory apparatus and became of commercial value.

Recent hydro-electric developments, with consequent cheapening of electric power, and splendid research work in the electro-metallurgy of iron and steel, have already led to such results as the partial elimination of the crucible furnace, a strong competition with the Bessemer converter and open-hearth furnace, and even the bringing forward of a rival to the blast furnace.

All furnaces require a heat supply for their operation, and are alike in this respect; whether the heat is derived from gas, coal or other fuels—as in ordinary furnaces—or from electrical energy in the electric furnace.

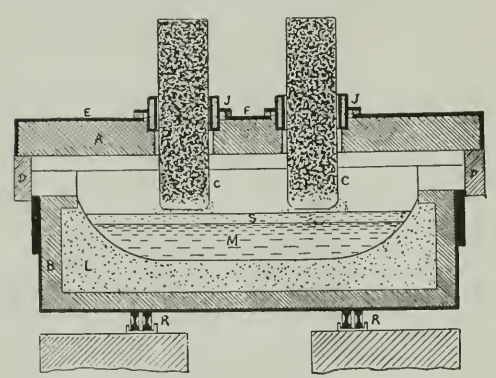


Fig. 1—Sectional Elevation of Heroult Furnace.

Defining the efficiency of a furnace as that proportion of the heat value of the fuel (or electrical energy) that is actually utilized in heating the contents of the furnace, we have the following table of typical efficiencies for various furnaces:

Type of Furnace.	Heat Efficiency. Per cent.
Crucible steel furnaces, coke firing.....	2— 3
Reverberatory furnaces	10—15
Regenerative open-hearth steel furnaces..	20—30
Shaft furnaces (foundry cupolas, etc.)...	30—50
Large electric furnaces.....	60—85

With the exception of induction varieties, all electric furnaces are of the arc or resistance type, or a combination of these two, and require some form of electrode, usually carbon or graphite. A brief description of typical furnaces, showing methods of supplying energy, may be of interest.

The Heroult furnace, shown in Fig. 1, is of the combined arc and resistance type, two or more electrodes being used, the current passing from one electrode down through the slag, across through the bath and up through the slag to the other electrode. As the resistance of the bath is small compared to the resistance of the slag and arc, most of the heat is generated at its surface, where the chemical action is going on between the slag and the metal.

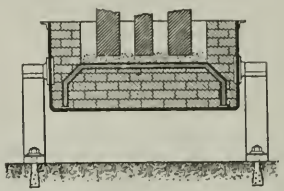
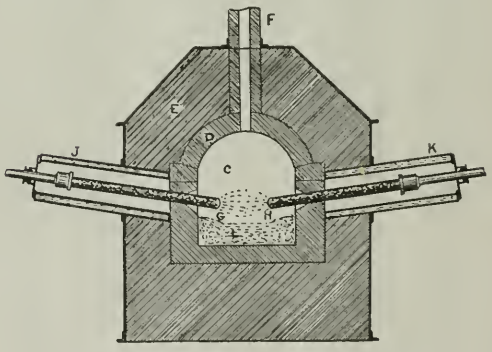


Fig. 2—Sectional Elevation of Girod Furnace.

The Girod furnace is similar to the Heroult furnace, with the exception that all the electrodes are connected to one side of the line, the water-cooled bottom being connected to the other side (see Fig. 2). In this furnace the current passes from the electrode through the slag to the bath, thence through the metal to the bottom and out.

Fig. 3 illustrates the Stassano furnace, which is of pure arc type, the heat being obtained from an arc, drawn out between two or more carbon electrodes, which passes over but does not come in contact with the charge. This arc with less than 200 volts sometimes reaches a length of three feet or more.

The Colby, or Kjellin furnace, is of the pure induction type, without electrodes, the bath forming the short-circuited secondary winding of the transformer, and being heated by the enormous currents induced from the primary windings. A vertical section of the furnace is shown in Fig. 4.



Sec. 3—Sectional Elevation of Stassans Furnace.

The Roechling-Rodenhauser furnace (Fig. 5) is of the combined induction and resistance type, the greater part of the energy being furnished by induced cur-

*From the General Electric Review.
†Power and Mining Engineering Department, General Electric Company.

rents, and a small part by a current passing between auxiliary electrodes placed at the slag line which come into action only when the furnace is hot. These electrodes are constructed of a heat insulator, which is also an insulator of electricity when cold but which becomes an electrical conductor when hot.

The electric furnace has been used with success in refining steel, smelting pig iron, and in producing steel direct from the ore itself. In smelting pig iron, using high grade ore, from 1,500 to 2,000 kw. hours are required per ton of iron produced. In addition to the electrical energy, which supplies the heat of fusion, approximately 800 pounds of coke are required for the reduction of ore. This is considerably less than the consumption of 2,000 pounds required in the ordinary blast furnace (which, however, also supplies the heat at fusion), and the difference in favor of electric furnace increases as the quality of ore decreases.

Assuming a heat efficiency of 25 per cent for fuel and 75 per cent for electricity, then electricity is cheaper than coal when one ton of coal costs twice as much as one electrical horsepower year. The energy required for smelting a ton of iron has varied in various experiments from 0.214 kw. years, to 0.250 kw. years.

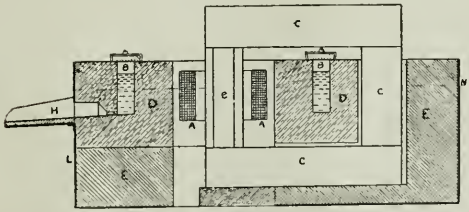


Fig. 4—Sectional Elevation of Kjellin Furnace.

In a run of 30 days, made by the Noble Electric Steel Company, Shasta County, California, the furnace operated for the first 25 days, producing 14 tons of iron with a power consumption of 0.435 kw. hours per ton; for the remaining 14 days of operation the power input was increased, resulting in a production of 0.250 kw. hours per ton. This furnace is being extended to produce from 15 to 20 tons per day with an approximate input of 1,500 kw.

The following table gives the composition of four bars of pig iron recently made in this furnace:

	1.	2.	3.	4.
Silicon	0.47%	0.51%	5.72%	5.70%
Sulphur	0.044	0.046	0.009	0.009
Phosphorus	0.051	0.041	0.053	0.053
Manganese	0.03	0.03	0.18	0.18
Total carbon	2.65	2.06	2.56	2.82
Combined carbon	....	....	2.20	0.15

As all four specimens were made in the same furnace, this illustrated how the use of the electric furnace permits the operator to vary the chemical composition of the product as desired. An estimated cost of operating a 1,500 kw. furnace producing 15 tons per day, based on experience obtained in operating the 200 kw. furnace, would be as follows:

22.5 tons of ore at $1.75	$ 39.60
1.5 tons of limestone at $1.00	1.50
1.5 tons of andesite at $1.00	1.50
6 tons of charcoal at $10.00	60.00
3 furnace firemen at $3.00	9.00
3 charging men at $2.50	7.50
3 men for fixing charge at $2.50	7.50
1 electrician at $3.00	3.00
Total	$204.60

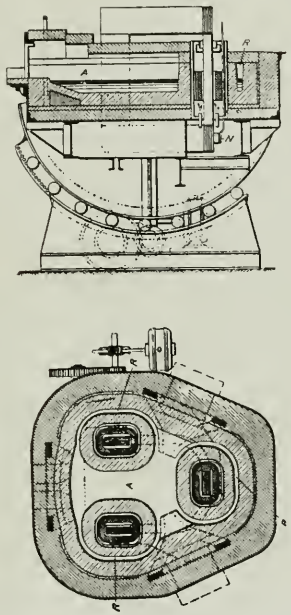


Fig. 5—Plan and Elevation of Roechling-Rodenhauser Furnace.

This makes $13.64 per ton, to which $2.50 is added for incidentals, making a total cost of $16.14, which, with a freight rate of $2.50 per ton from this plant to San Francisco, gives a very reasonable margin of profit with a selling price of $28.00 per ton.

The ordinary blast furnace will not satisfactorily handle an ore having more than 0.15 per cent. sulphur, while a very good pig iron has been produced in the electric furnace from ores containing ten times this percentage.

The formation of cyanides in a blast furnace is caused by the nitrogen of the blast in the presence of a basic slag, the nitrogen combining with the ferrite to form a nitride, the presence of which makes the iron brittle. From this it follows that nitrides may be formed in any air blast process, with attendant injurious effects on the mechanical properties of the product, and explains why certain steels with low sulphur

and phosphorous contents shows unaccountable brittleness. As the electric furnace uses no blast, nitrogen is eliminated, and the product is free from this fault.

For this same reason the gas issuing from the electric furnace will be much more suitable for combustion under boilers and in gas engines than that obtained from the blast furnaces, as it contains many more heat units per pound than the latter. In addition to avoiding the formation of nitrides of iron, the smelting is done in a neutral atmosphere and almost absolute control of the chemical composition and temperature is obtained, a condition not to be found in any other furnace.

Where coke is not obtainable or only to be had at a prohibitive cost, charcoal made from waste ends and mill refuse may be substituted and serves as an admirable reducing agent. On account of the magnetic properties and electric conductivity of magnetite considerable difficulty was expected, due to increased inductance and difficulty in concentrating the current in sufficient density to produce the high temperature necessary for fusion and reduction; no troubles directly traceable to these phenomena were experienced, however.

The amount of steel manufactured in the United States in 1906 was approximately:

Bessemer steel	12,000,000 tons
Open hearth steel	11,000,000 tons
Crucible steel	118,000 tons

Of this production, all of the crucible steel and a considerable percentage of the open hearth and the Bessemer steels can be produced in the electric furnace, with a great saving in the case of the crucible steel and a slight additional cost in the case of the other steels. For the crucible steels alone this would require approximately 40,000 kw. of installation.

When we consider the tonnage of crucible steel referred to above, and that every ton requires from 20 to 25 crucibles, with consequent breakage, high labor charge and danger to workmen, it becomes evident that a tremendous saving can be effected by the use of a furnace having a capacity equal to the modern open hearth furnace and a product equal or superior to the best crucible steel. This becomes more evident when we realize that the number of men necessary to operate this furnace is only a slight percentage of that required to operate a crucible furnace, and that the charge itself may consist of a very poor quality of scrap in contrast with the carefully selected material necessary for charging the crucibles.

The tremendous expense and trouble required by the crucible furnace is evidenced by the fact that 1,768 crucibles and the services of 490 men were required in the recent casting of an 80-ton ingot at the Krupp Works. This plant has a separate building for the manufacture of crucibles, with a capacity of 2,000 to 3,000 per day.

Without referring, at present, to the production of steel direct from ore, two methods of refining steel are used in the electric furnace, viz.: cold charging and hot charging.

In cold charging, the scrap metal is placed in the furnace and melted down by the electrical energy, in which case approximately 550 to 600 kw. hours are required per ton of steel. The other method is to take the superoxidized metal from the Bessemer or open hearth furnace and refine it in the electric furnace; in which case approximately 250 kw. hours are required per ton of steel.

In a German plant a 250-h. p. electric furnace, having a capacity of 2,200 pounds per charge and operated by three workmen, replaced a bank of 32 furnaces, each containing 6 crucibles with a capacity of 77 pounds each. With this furnace, using ordinary turnings and waste wrought iron costing approximately $13.00 per short ton, a fusion requires 3½ hours, with 1½ hours more to complete the refining process. The total cost per short ton of tool steel produced in this furnace is as follows:

Depreciation and interest	$ 1.09
Raw materials, including ferro alloy, etc.	15.13
Power, including heating between runs	9.75
Renewal of lining	2.59
Labor	2.16
Electrodes	.55
Water for cooling	.11
Total	$31.38

This type of furnace is not as efficient in power consumption as other furnaces, and even with cold charging, a power consumption of 900 kw. hours per ton is high; in addition the power rate was $70.00 per horse-power year, making the cost of this item excessive. Under similar conditions, viz., cold charging, tool steel has been produced with a consumption of 600 kw. hours per ton; with power rates at $30.00 per horse-power year, this item becomes $2.75 or a saving of $7.00 per ton.

It has been proven that one of the most serious causes of brittleness in steel is the presence of manganese sulphide. This can only be removed by allowing the refined metal to stand a sufficient time for the sulphide to rise to the surface of the steel and be removed as slag, or by having the bath so free from sulphur that this compound cannot be formed except in minute quantities, and if a low sulphur ore is not available to start with, electric refining must be used.

The electric furnace is very effective in removing sulphur, and when once the sulphur is removed there is no danger of further contamination, as in the open hearth furnace, where the charge may be contaminated by sulphur from impure gases. Even closed crucibles are not wholly proof against leakage, and this trouble may become serious with very impure gases.

As sulphur combines in the steel bath forming sulphides that are soluble in the steel and slag, the quantity of sulphides passing into the slag depends upon the temperatures and basicity of the latter and its content of lime and manganeous oxide. In the electric

furnace practically any temperature may be attained, and consequently the basicity of the slag may be as high as desired.

As an example of the effect of removal of sulphur in the electric furnace, the analysis of 1,000 successive charges gave the following results: 743 specimens had a sulphur content not greater than 0.010 per cent, while 958 specimens contained not more than 0.015 per cent. These results were not due to the use of especially pure raw materials, as the sulphur content of the charge varied from 0.035 per cent to 0.500 per cent.

Steel direct from ore has been the ideal of the manufacturer, in view of the possibilities of increased production with consequent lowering of cost.

Steel has been produced direct from ore in the Stassano furnace with a consumption of 0.585 horsepower years per ton of steel, using ore with a sulphur and a phosporus content of 0.120 and 0.150 per cent, respectively, the product with a carbon content of 0.800 per cent phosphorus. This steel had an ultimate breaking strength of 111,000 pounds per square inch with 13 per cent elongation.

A process developed in this country and known as the Lash process, produces steel direct from ore, coke, and cast iron high in metalloids. The metalloids contained in the cast iron appear to act as reducing agents; from which fact we suppose that carbide of iron (as Fe3 C) acts as a reducer. Besides these main constituents, lime or other fluxes may be added, sawdust to make the mixture porous, and some suitable binder when it is desired to briquette the mass.

The advantage of using this process is due to the greater cheapness of iron in the form of ore; so that, other things being equal, the greater the proportion of iron in the form of ore, the cheaper the product will be. In some experiments at Niagara Falls with this process it was found that steel was produced with a consumption of 0.27 horse power years per ton, and even with this small power consumption an excessive amount of energy was used owing to the inexperience of the operators.

A three-ton furnace was used in these experiments, and about fifty tons of steel was obtained, in the form of ingots varying in weight from 200 to 425 pounds. The mixture used for the most part consisted of 60 per cent iron ore, 23 per cent cast iron, and the remainder of fluxes and carbon, the cast iron being in the form of borings and shotted pig iron.

In the preliminary experiments, as much as 15 per cent of the iron was lost in the slag, this being reduced, however, in later runs to 6 per cent and eventually even lower figures. While the power consumption of this process is less than half that required in the Stassano experiments, the electrode consumption is much greater; but in all probability the saving in power will overbalance the loss due to excessive electrode consumption.

That the electric furnace is gaining favor in steel refining is evident when we consider that there are 43 furnaces now in operation having a combined capacity per charge of 251,000 pounds; and 36 in course of construction, of which 28 have a combined capacity per charge of 278,000 pounds, 8 as yet being undetermined. The largest furnace yet designed and in operation has a capacity per charge of 12½ tons, and a power input of 1,200 kw. Most of these installations are in Europe, but in view of the rapidly awakening interest in this country we may expect great advances in the near future.

With pioneer electric furnaces, having outputs in the neighborhood of one ton per day, competing with the perfected modern blast furnace under the special conditions of cheap electric power and expensive metallurgical fuel, what may we not expect of the electric furnace when perfected by wide experience, and when the increased demand for fuel and the exhaustion of high grad ores shall have led to the inevitable handicapping of our present methods?

MANUFACTURE OF ETHYL ALCOHOL FROM SAWDUST.*

By G. U. BORDE, M. E.

I have just returned from Europe where I went to investigate the manufacture of ethyl (grain, not wood) alcohol, acetic acid and stock food, out of sawdust.

In France I found that a company was organized, the aim of which was to control the entire output of the sawdust in France; which, by the way, is only the equivalent of wood waste given out by one of our sawmills having a capacity of 750,000 ft. board measure per day.

One of the principal stockholders in this concern is the largest distiller and exporter of French cognac in France, and his object in obtaining control of this company was to have the exclusive right to the alcohol made from the sawdust so that he could use it in the rectification of brandy. He admitted that he exported to England alone 50 per cent more French cognac than the entire crop of France,and that he also sold to the balance of Europe and to the United States as well. Up to the present time he had been using alcohol made from beet sugar for the rectification. Samples of the alcohol submitted to the experts in the alcohol exchange of Paris were declared to be equivalent if not superior to the alcohol distilled from grapes—so much for the quality of the product.

The process used is one discovered by Dr. Alexander Classen of the Polytechnic School of Aachen, Aix la Chapelle, Germany, in 1900. He found that he could convert the cellulose existing in all woody fibre into a fermentable sugar by cooking the wood under pressure in the presence of sulphurous acid, and then by fermenting the sugar thus formed, obtain ethyl alcohol. This process he patented all over the world; but his original methods were crude, and the French people, after having purchased the patent rights for

*From the Manufacturers' Record.

France, set to work to develop the process commercially. They changed the design of the apparatus suggested by Dr. Classen for the conversion, and further experimenting found that, in addition to the sugars formed, a considerable quantity of acetic acid was produced at the same time; and so in their process they have made arrangements to extract the acetic acid as well as the alcohol.

At St. Marcel I found one of these plants in the course of construction, and the management kindly turned it over to me for experimenting. Twenty tons each of cypress shavings and long leaf yellow pine sawdust had been shipped from the South, and twenty tons of mixed hard woods from Chicago. While the plant was in course of construction enough of the apparatus was in place to carry the process through successfully, but enough was missing to prevent me from getting an absolutely accurate estimate of the cost of manufacture.

It makes practically no difference what kind of wood is used for the manufacture of alcohol, as all yield the same amount of alcohol per ton of wood. Oak, however, on account of the excessive amount of tannic acid which it contains, and which is a foe to fermentation, has to go through an additional treatment for the elimination of this acid before it can be fermented and its sugars converted into alcohol.

In a general way the process in this plant is as follows:

The sawdust, which is drawn from a radius of about 75 miles from the plant, is put into a digester, and a predetermined amount of water and sulphurous acid is added. The digester is closed and sealed and external heat applied until the pressure inside reaches about 100 pounds at which pressure the contents are kept for a certain length of time, during which the cellulose in the wood is converted into dextrin and other sugars. The heat is then cut off and the usual sulphurous acid, which has been put into the digester simply to get the pressure to the required point, is reclaimed. The material in the digester, which has shrunk about 25 per cent, is then passed over to the separator, in which the acetic acid formed during the conversion is vaporized by means of a steam jet and then collected. The converted sawdust is then brought over to the mash tanks where its acidity is neutralized, and it is made into a mash which is fermented and distilled in the same way that an ordinary grain mash is handled in a whisky distillery.

The tailings from the still are first compressed to extract the water and the final amount of moisture is taken out in a dryer heated by waste gases from the boilers. In France and England, these dry tailings are made into stock food or brickettes; or by the addition of a small amount of magnesia, are compressed into an artificial fireproof stone which has a crushing strength of 18,000 pounds per square inch and a tensil strength of 6,000 pounds.

Other experiments are being carried on at present for further results from these tailings, and while not at liberty to make public what these experiments are, I venture to predict that there is a good deal more in the tailings than has so far been got out of them.

The results obtained from the wood shipped from America were as follows:

For every 3,200 pounds of green refuse, which contains about 30 per cent moisture and is the equivalent of one long ton of theoretically dry wood, we obtained 21½ gallons of 188° proof alcohol, which is the equivalent of 38.6 gallons of proof alcohol. By experiment in the laboratory, we found that this yield should have been about 10 per cent higher, which loss was probably due to our inexperience in handling the apparatus.

In addition thereto will be obtained 76 pounds of acetic acid and ¾ of a ton of refuse, the latter being manufactured into stock food by the English and the French people.

The French chemist of the concern claims that under proper manipulation of the apparatus and when everything is in working order, they obtain from their wood—and we should from ours—30 gallons of alcohol per ton of sawdust.

It is estimated that for every ton of theoretically dry wood, or in other words, for every 3,200 pounds of green sawdust, one should obtain:

30 gallons of 188 deg. alcohol at 40 cts. per gal.	$12.00
76 pounds of acetic acid at 6 cts. per pound	4.56
¾ ton of stock food at $23.00 per ton	17.25
	$33.81
Less estimated cost of production	7.00
Net profit	$26.81

If one takes into consideration that 1,000 feet board measure of green lumber is the equivalent of 1¼ long tons of theoretically dry wood, this would make the net return of $33.51 per 1,000 feet board measure.

This to the skeptic may sound like a wild dream, but the facts given in this article are based on actual results. Some people who have had occasion to look into this matter further, have determined to go ahead and erect plants for the manufacture of alcohol, acetic acid and stock food from wood waste, and I am at present designing a plant to be erected in Hadlock, Washington, having a capacity of 50 tons of sawdust per day, and another to be erected in Ontario, Canada, with a capacity of 100 tons of sawdust per day. These plants I hope to have in successful operation by the first of the year, and the day will not be far distant when it will pay the sawmill owners to go more deeply into the question of economy of waste material in the woods, as well as waste of power in the plant.

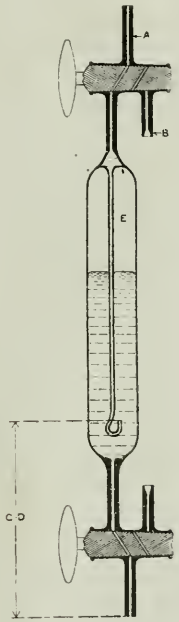
If it is figured that so-called wood waste returns only $10.00 per ton instead of $26.81, and further, that it takes at least two tons of wood waste to equal one ton of coal in the production of steam, the sawmill owner will have to admit that the time to economize has arrived.

THE LABORATORY.

A NEW GAS SAMPLING TUBE.*

By G. NEVILL HUNTLEY, B. SC., F. I. C.

In a boiler trial it is required to take an average sample of the flue gases extending over the whole trial. For this purpose a rapid stream of gas is drawn by suitable means from the flue through a wide tube, and the latter tapped by the laboratory sample tube. Assuming that the gas in the main tube represents



Sketch of Gas Sampling Tube.

the average of the flue gas, the following conditions must be satisfied by the laboratory sample.

1. Since mercury is used as the confining fluid, the tube sample must necessarily be small.

2. The gas must be drawn into the sample tube at a uniform rate per hour.

3. The gas in the dead space between the main tube and the sample tube must be eliminated.

4. The gas in the sampling tube must not be allowed to diffuse back into the main tube, or to be drawn back into the main current by sudden changes of pressure.

The usual pattern of tube, with single stopcocks at each end, does not fulfill conditions 2, 3 or 4. The replacement of the single stopcocks by double ones, described by Haldane, eliminates the dead space difficulty, and much facilitates the transference of the gas in the laboratory Stead's gas sampler, which is much used, allows the dead space to be cleared when starting to take the sample, but not on transference of the gas. Back diffusion is supposed to be prevented by the small U at the top; in the four that I have used this has not worked, the mercury in the U being carried over with the first bubbles of gas. Possibly these tubes were not constructed according to the original design. The rate at which the gas is drawn in is not constant, and frequent regulation of the drip tap is essential if this condition is to be even approximately fulfilled.

The tube figured satisfies conditions 2, 3 and 4. The gas is drawn in at A. The dead space is cleared by sucking at B. The rate at which the gas is drawn in is fixed by the tap and the distance CD, and the latter can be increased by joining on a glass tube with rubber to D. It is obvious that the gas cannot be sucked back or diffused back. It has been found by trial that the rate at which the gas is drawn in is constant throughout within 1 per cent. A slight inclination of the tube from the vertical gives a sensitive fine adjustment.

*From the Journal of the Society of Chemical Industry, March 31, 1910.

Tungsten salts are used in fireproofing cloth for curtains and draperies; in weighing silks; in glass making, as a mordant in dyeing; and for other purposes.

The Gorbov and Mitkievitch arc furnace for the fixation of atmospheric nitrogen is about to be worked in Russia on a technical scale. In this the current of air draws the arc (the voltage across which is 600-1,500, direct or alternating) into a worm, in whose mouth is formed a "bunch of fire" through which all the air has to pass. The products of combustion are subsequently cooled in the farther part of the worm. In an experimental 14-kilowatt furnace an output of 56 grams HNO_3 per kilowatt hour has been attained. The furnace is stated to be simpler and more economical than the Birkeland-Eyde furnace.

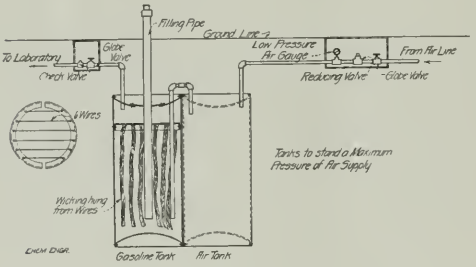
A GAS MACHINE FOR A SMALL CHEMICAL LABORATORY.

By VICTOR V. KELSEY.

The Carolina Clinchfield and Ohio Railway Company has recently installed at Erwin, Tenn., a chemical laboratory to meet the needs of the Motive Power and Industrial Departments of their road.

In equipping this laboratory both first cost and economy were considered, resulting in several new features being worked out. One of the first questions to arise was that of a gas machine which would supply about 25 burners including a double burner Vulcan stove.

The machine as finally built is shown in the accompanying sketch, and as will be seen, consists of two tanks, one to contain the gasoline and the other an auxiliary tank for the air supply which is conducted into it through a one-half inch pipe connected to the air main which supplies the various shops at a pressure of 90 pounds per square inch. To reduce this pressure so that it may be brought to a pressure of about 5 pounds for use in the laboratory, a reducing valve was placed between the air tank and supply main. Between the reducing valve and the air tank a



Sketch Showing Arrangement of Gas Machine.

low pressure gauge was placed. A globe valve was so placed that the air pressure could be cut off before it reached the reducing valve. This valve, the reducing valve, and the air gauge were enclosed by a small wooden box below the ground level and at a convenient distance from the laboratory.

The gasoline tank contains wicking hung from wires stretched across the tank near the top supported by small angles riveted to the inside. In order to place these angles inside the tank a hole was cut in the head, which was afterwards sealed with a plate securely riveted. This tank is supplied with gasoline through a one and one-half inch fill pipe which extends from 3 inches above the bottom of the tank to 8 inches above the ground level. A small hole was drilled in the fill pipe at a point just below the head of the tank to allow the gas which had accumulated in the pipe to escape and thereby facilitate the refilling of the tank.

A globe valve is placed in the line from the tanks to the laboratory. There is also a check valve to prevent any possibility of lighting back.

The tanks used are similar to those used as air reservoirs on locomotives and are of sufficient strength to stand a pressure of 125 pounds per square inch which insures perfect safety. They are placed about three feet underground and at a safe distance from the building. Each tank has a capacity of approximately 20 gallons. To allow for room for the generation of the gas, the gasoline tank is not filled to more than two-thirds its capacity.

The cost of this machine was very low, and so far the machine has proven an efficient one for the class of work for which it was intended.

At the second annual meeting of the American Institute of Chemical Engineers, held at the Hotel Clifton, Niagara Falls, Ont., the programme provided for the presentation of technical papers on the following subjects: "Changes in Industrial Chemistry Caused by Electricity," by Mr. E. R. Taylor; "Notes on the Corrosion of Iron and Steel and Its Prevention," by Mr. C. W. Thompson; "Vacuum Distilling Apparatus," by Mr. P. B. Sadtler; "The Study of Materials as an Element in a Course of Chemical Engineering," by President McKenna; "A New Product for Use in the Arts," by Mr. F. G. Weichmann, "Chemical Industries of Canada," by Mr. I. A. De Cew; "The Manufacture and Industrial Application of Ozone," by Mr. Oscar Linder; "Problems in Chemical Industry," by Mr. J. T. Baker; "Arrangement of Filter Presses for Bleaching Oils with Fuller's Earth," by Mr. David Wesson; "Commercial Manipulation of Refractory Elements for Incandescent Lamps," by Mr. R. E. Myers; "Underground Waters for Manufacturing Purposes," by Mr. W. M. Booth; "Loss in Coal Due to Storage," by Mr. A. Bement; "Nitric and Mixed Acids," by Mr. Schuyler Frazier; "Plant Design," by Mr. W. M. Grosvenor.

Several counties in New York State have established health laboratories. Legislation authorizing this was recently passed by the State Legislature. Any board of county supervisors in the State is authorized to establish such a laboratory and provide necessary equipment and staff. It appears that all local boards of health and physicians may avail themselves of the services of such laboratories in counties where they have been established, provided the services requested have a direct relation to public health. It also appears that analysis not related to the public health may be secured on payment of moderate fees.

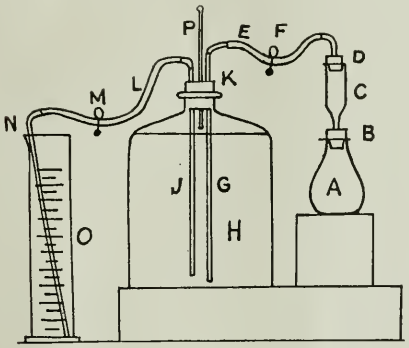
The exports of manganese ore from Russia during the year 1909 amounted to 611,000 tons, as compared with 440,000 tons in 1908 and 608,000 tons in 1907, showing an advance last year of 171,000 tons over the previous year, and of 3,000 tons over 1907.

EASY PROCESS FOR ESTIMATING WATER IN PETROLEUM.*

By R. RIGHTWICK ROBERTS and ALFRED FRASER.

A large portion of California petroleum—or rather petroleum residues, for it has been freed from the lighter oils by distillation—that comes to the coast of Chili for use as fuel, contains quantities of water varying up to about 20 per cent. This water seems to form an emulsion with the heavier constituents of the oil, and, besides detracting from its calorific value, causes at times serious trouble by clogging the nozzles of the blowers.

As the estimation by distillation is difficult and often unsatisfactory, the attempt was made to determine the water by adding calcium carbide to the oil and measuring the amount of acetylene given off. The experiment was entirely successful. A number of concurrent tests were made (1) by taking two equal portions of the same oil, adding a weighed quantity



Sketch Showing Arrangement of Apparatus.

of water to one, treating both with carbide, and taking the difference in the amount of acetylene given off, and (2) by treating a portion of oil with excess of carbide, till no more gas was evolved, adding a weighed quantity of water, and measuring the acetylene subsequently given off. The two tests gave an average of 580 cc. (at 0° C. and 760 mm. barometric pressure), per gram of water in the sample; a number which agrees very closely with that obtained by P. V. Dupre in his somewhat similar experiments on the determination of moisture in cordite.

APPARATUS.

In the apparatus shown in the accompanying sketch, *A* is an Erlenmeyer flask of about 300 cc., *B* is a perforated india rubber stopper, *C* a cylindrical glass funnel with perforated stopper, *D*; *H*, a bottle of about 5 litres capacity, with an india rubber stopper, *K*, with four perforations, through two of which glass tubes, *G* and *J*, reach to the bottom of the bottle. *G* is connected with the funnel, *C*, and *J* with the long glass tube, *N*, by means of india rubber tubes, *E* and *L*, with clips, *F* and *M*. The tube, *N*, dips into the graduated litre measure, *O*. Through another hole in the stopper, *K*, is inserted the thermometer, *P*, while through the fourth passes a glass tube with cock (not shown in the diagram), connected with a suction pump.

The bottle, *H*, is filled with a saturated solution of common salt, and, by blowing gently at *D*, the tube, *N*, is filled with the solution and the clip, *M*, is closed. The flask, *A*, is tared, and 17.24 grms. of the petroleum to be tested are weighed into it. If this is very thick, as is usually the case, about 20 cc. of kerosene are added and well mixed with the thick oil. The clip, *F*, being open, and the measure, *O*, empty, a few fragments of calcium carbide are dropped into the funnel, *C*, then about 20 grms. of finely ground carbide are poured on the top of the loose fragments, the stopper, *D*, is quickly inserted and the clip, *M*, opened. A few taps with the finger causes the finer carbide to fall gradually into the flask, *A*, which is gently shaken. The evolution of acetylene commences immediately, and this, passing through the tube, *G*, into the bottle, *H*, causes an equal bulk of water to flow into the measure, *O*. If there is a large quantity of water in the sample and the flask, *A*, becomes warm, it is immersed in a beaker of cold water to keep down the temperature and prevent the distillation of any gas from the oils. When the evolution of acetylene ceases, and no more is produced by a brisk shaking of the flask, *A*, after it has stood a minute or two, the reaction is considered finished. The measure, *O*, is now raised so that the water in it may stand at the same level as that inside the bottle, *H*, and allowed to remain so a minute or two for the levels to adjust themselves; then the reading of the thermometer, *P*, is taken, the clips, *F* and *M*, are closed, the tube, *N*, is withdrawn, and the amount of water in the measure read off. The proper correction for temperature and barometric pressure having been made, each 100 cc. of the reduced volume indicated 1 per cent of water in the sample. The whole operation occupies from 15 to 20 minutes.

In the first tests that were made the saline solution was run from the tube, *N*, into a tared flask and weighed, and, its specific gravity having been taken, its exact volume was easily calculated. A correction was also made for the amount of acetylene dissolved by the oils in the flask, *A*. The saline solution in the bottle, *H*, was also first saturated with acetylene so that it could absorb no more from that given off by the sample.

Several tests may be made without refilling the bottle, *H*. To refill this the tube, *N*, is dipped into a large flask or beaker in which the saline solution has been collected from the various tests, the clip, *M*, is opened and also the cock of the glass tube which goes to the suction pump, and the solution sucked back into the bottle, *H*. This also prevents the acetylene polluting the air of the laboratory. We are indebted to Mr. J. Southward for his valuable help in carrying out the details of this investigation.

*A paper presented before the Scottish Section of the Society of Chemical Industry and printed in the Journal of the Society.

METALLURGY.

MODERN CUPOLA PRACTICE.*

By JOHN C. KNOEPPEL.

Foundry owners frequently wonder why they are having trouble with their iron, blaming almost everything but their management of the cupola. This has not received the attention that it should, and as a usual thing the cupola is considered foolproof, in fact, is expected to run itself. Good work with the cupola is first of all dependent upon a thorough knowledge of the cupola and its performance while working under the blast. The construction must next be such that the proper amount of air can actually get in, and in such a way that the temperature conditions are as uniform as possible, so that cold spots are avoided. The tuyere area must be of such a size and so arranged that the blast enters the cupola without undue friction.

PREPARING FOR THE CHARGE.

The ultimate shape of the cupola lining, if allowed to take its own course, will be found to be slightly built out above the tuyeres, and this is an argument that, if left that way, it is most desirable for efficient work. Hence in chipping the cupola and daubing up, it were best left so that only the refuse matter and iron above the tuyeres is taken away, but that this natural shape is left intact. The daubing can be very light, and cracks filled with small broken firebrick or flat brick, as the condition may require it. As the heat at this point becomes very intense, there is a tendency for the daubing to crack off long before melting is in progress. This material falls into the stock and retards melting afterward.

Bottom is put in so that the surface, while dipping from back and sides to the spout, does not fall too steep, as the melted material will run downward with two much force, causing trouble in tapping during the heat. It should be so made that the iron will lie quietly on it and not injure or break through it. The necessary shavings and kindling are now put in, the latter being laid by a man in such a way that when burning it will do so evenly and without injury to the bottom. Coke is now thrown in and allowed to burn through evenly. When up to proper height, as indicated by wire gauge or other suitable method, charging may begin.

DETAILS OF CHARGING.

Charging should commence at least 2 hrs. before the blast is put on, so that the stock may become well heated through, and the time for lighting up should be arranged accordingly. There should be neither too much nor too little coke on the bed. Oftentimes the cupola man is allowed to take all he wants, and the result is a prolonged heat, with dull iron instead of the expected hot material. The iron charged should be of medium size, especially in small diameter cupolas. There should not be too many openings for the free passage or rather escape of the blast. In large cupolas, while the stock can be larger, it should not be charged in too compact a way, thus retarding the blast.

The amount of the bed of fuel for a cupola is determined by a number of factors: The diameter inside the lining, the height of the tuyeres, blast pressure, class of work, etc. For light work, with practically continuous melting and pouring, the tuyeres should be set low, thus saving fuel for the bed.

The bed should extend from 20 to 24 in. above the top of the tuyeres, whether one or two sets are used—above the top of the upper if the latter. On the other hand, the tuyeres must not be set too low, otherwise if any iron is to be held it will be chilled if remaining in too long. From 12 to 16 in. from the bottom plate to the bottom of the tuyeres would seem about right for ordinary practice, the bottom being from 4 to 6 in. thick.

SLAGGING.

Slagging when the tuyeres are very low often does more harm than good; it retards melting and is destructive to the cupola lining. If the heats are heavy, so that slagging must be resorted to, it is better to put the tuyeres up higher in the first place. The slag hole should not be opened until the slag is high enough to reach it; usually 10 tons or so of metal will have passed out by that time.

In large cupolas for medium heavy work the tuyeres are usually set from 18 to 24 in. from the bottom. The higher they are set the more fuel is required for the bed. More air must be forced through or else melting is unduly slow. High melting zones and blast pressures have a tendency to harden the iron, make more slag and give trouble generally.

The charges of iron should be uniform, the first being as large as the last. While undoubtedly more iron could be carried on the first charge it would mean lowering the bed unduly with subsequent trouble, as the coke charge coming down will not restore the bed to its full height again. It is the best kind of practice to maintain the bed at its proper height at all times, and this can only be done by small and equal charges of metal and the proper proportion of coke between them.

In long heats of high tonnage it is oftentimes a good practice to help build up the bed by adding additional coke at intervals. Experience will show this

*Paper read before American Foundrymen's Association.

best. The writer has always had better results with such small charges. The melting was more uniform and more rapid, with hotter and better iron. With heavy charges the melting difficulties result in giving metal with compositions different from the expected, and the chemist gets the blame which really belongs to the foundry manager.

THE VOLUME OF AIR IMPORTANT.

The construction of the cupola should be such that the air entering has great volume at low pressure rather than vice versa. Good lining material should be used, preferably double up to the charging door and single from there upward. The clay-wash should be mixed a day previous to use, and the addition of a little salt helps to tighten the joints. Space is left between the lining and the shell—about half an inch—and this filled up with a grout of old firebrick, ground up, and clay. The lining at the melting zone, as stated previously, is allowed to take its own shape during the heats, being originally straight like the rest of the construction. If this is done the melting capacity will be found increased. While this is the experience of the writer, he does not wish to be understood as advocating a contracted hearth construction.

Fuel that burns up fast, such as coke, must necessarily be supplied with a sufficient amount of air in quick time. The design of the tuyeres, therefore, plays an important part in this. The writer has found that a continuous tuyere of proper design gives the most uniform distribution to all parts of the cupola furnace. The velocity of the air is reduced and the best kind of melting is obtained.

When it is considered that to melt 10 tons of iron about 300,000 cu. ft. of air must be admitted into the cupola for that hour, it will be seen that the tuyere conditions must be such that a minimum obstruction shall take place before the blast actually is doing its work in the charges.

The coke below the tuyeres serves simply to hold the iron and support the stock. The temperature is far below that of the iron, and hence every pound thus used, unless for special reasons, is a direct waste. If the iron is held in the cupola too long the blast strikes over the top and injures it. Hence, while on general principles low tuyeres are advisable, they should not be so much so that the metal is damaged when carrying out the daily practice.

The charging door should be as high as conditions will permit above the bottom, so that the fuel will receive the benefit of the heat otherwise wasted. Ten to 15 ft. is the usual custom, though the distance is often made greater. Where a very high stack and charging door is used it is sometimes advisable to put in an intermediate door, so that in charging the first part of the heat the bed is not damaged. Further, it allows a more even charging. This intermediate door should be sealed up when the charging has reached that point, and then the upper door is used. The charging floor would naturally have to be constructed accordingly.

In every cupola, under the same conditions, there is a fixed melting zone. Below and above this the metal cannot be melted successfully. In either case the metal would be dull and damaged. This zone is determined by the cupola conditions and the volume and pressure of the blast. If the iron comes down within 10 mins. of the putting on of the wind it would indicate that the bed was of proper height. If it takes longer then the bed was too high. The excess of fuel must be burned away, and in doing this the iron is melted slowly and becomes dull instead of very hot. The melting zone is usually a space across the cupola about 4 to 8 in. high. Where the blast is heavy this is sometimes greater. A double set of tuyeres sends the melting zone up higher than is the case with one row.

THE FUEL RATIO.

Regarding the fuel ratio, this much may be said. What is economy in one foundry becomes a waste in another. The high melting ratios published are oftentimes very misleading. For general purposes 7 to 8 lbs. of iron to 1 of fuel is very fair. With the same sized small metal charges to coke between charges generally works out at 1 to 10. This can often be cut a little on the coke end if the bed is ample, especially at the end of the heat. As this work should not be left to the tender mercies of the cupola man, it is a good plan to hang up a chart of sufficient size in the charging room on which every charge is marked plainly, so that it can be followed without difficulty. All stock should be weighed, as even the coke will not run uniform in weight if measured in a basket. This is not with the idea that the fuel should be skimped, but simply to have the conditions in charging as perfect as possible, so that the best results may be expected and obtained.

For 20 years the writer has advocated the use of small charges and as mild a blast as possible, and he is glad to note that others are beginning to agree with him. The question of the tuyeres has been his special study, and he hopes that the system bearing his name may have helped to make the work about the cupola easier and the results surer. The cupola is not merely a vessel into which any old thing can be thrown and good results obtained, but it may become a money maker or loser just as one pleases. In these days of keen competition it becomes a problem not only to melt iron properly and economically, but to turn out a product that will give the smallest percentage of scrap castings.

The British Consul at Batoum reports that the quantity of manganese ore mined at Tchiaturi in 1909 was 451,600 tons, as compared with 358,423 tons in 1908. The quantity of ore transported by the Tchiaturi branch of the Trans-Caucasian railway in January, 1910, was 45,161 tons, and in February 67,887 tons This latter figure represents the greatest quantity of ore that the line has ever yet been able to carry in a single month.

THE NATURE AND TREATMENT OF ALLOY STEEL.*

By DR. JOHN A. MATHEWS.

Paraphrasing the remark that has been made about books we may well say, of making many alloys there is no end and much study of them is a weariness to the flesh and small profit to the maker. It is hardly necessary at this late day that an article upon this subject should consist of long tables of remarkable physical tests—elastic limits above 100 tons, coupled with the elongation of molasses taffy or illustrated with photographs of steel tied into bowknots and large forgings distorted in shapes that would make the "human snake" turn green with envy. Too often in the past such data have raised bright hopes in the mind of a steel consuming public, and too often results in practice have fallen short of published data and perchance aroused a suspicion that published data always represents freak material and freak treatments or that the photographs represent enlarged photos of wire sizes.

A few generalizations in connection with these recent fascinating developments in the steel industry may serve a more useful purpose and help the user to obtain in practice results equal to those claimed by the maker. Let us then begin with the definition that "steel is a malleable alloy of iron and carbon which has been produced by casting from a fluid mass."

Since by this definition all steel is an alloy, what is meant by "alloy" or "special" steels? While these terms are in general well understood, they are difficult to define, though they may be described.

COMPLEX COMBINATIONS.

Two elements, iron and carbon, are always present—silicon and manganese, which are useful and essential, and sulphur and phosphorus, impurities whose effects even in homeopathic doses are by no means negligible. Copper and arsenic, aluminum, oxygen, nitrogen and cyanides are usually present in minute and negligible quantities. Ordinary steel, by whatever process made, is therefore a wonderfully complex alloy, though often spoken of as though it were an elemental substance. It may contain carbon and manganese from 0.10 to 1.50 per cent.; silicon from 0.02 to 0.25 per cent; and sulphur and phosphorus from 0.01 to 0.10 per cent; and the other elements named above which are rarely determined. Its complexity is further increased by the fact that iron and carbon may exist in several different physical conditions or combinations, while the intramolecular possibilities of the other elements are legion.

When to this very complex base material, other elements such as nickel, chromium, tungsten and vanadium are added, we begin to look wise and talk about alloy steels. Steels within the limits of analysis just mentioned serve an enormous number of purposes, and steel of a particular analysis adapted for rails, springs, knives or gun barrels may in a limited sense be called a "special" steel, but such is not the commonly accepted use of the term.

EFFECTS OF ADDITIONS TO CARBON STEELS.

When we materially exceed the limits just given or add elements not normally contained, such as nickel, vanadium, chromium, tungsten, molybdenum, etc., the product is called an alloy or special steel. Silico-manganese gear steel is an instance of an alloy steel containing no unusual elements but containing some of the ordinary elements in unusual amounts. Its analysis is about as follows: Carbon 0.50 per cent; silicon 2.00 per cent; manganese 0.60 per cent.

In such a case it becomes difficult to decide arbitrarily the percentage at which we pass from a regular to a special steel. Abnormally increasing the ordinary constituents or adding other constituents so changes the properties that new qualities appear and new purposes are served. The effects of such additions are made manifest in various ways which may be summarized as follows: 1. By changing the critical ranges and recalescent temperatures. 2. By modifying the condition in which the carbon exists. 3. By removing harmful occluded gaseous impurities. 4. By combining other elements chemically with iron or carbon or both, and 5. Presence of other elements either combined or free, forming isomorphous solutions with iron or separating into distinct microscopic particles. By these means steel is improved or injured, hardened or strengthened, toughened or embrittled.

Notwithstanding its complexity, it is reasonable to expect, and much evidence has been brought forward to show, that steel and its alloys obey the laws of physical chemistry which hold good for simpler and purer alloys, namely, the laws of solution. The problems presented by steel alloys have engaged the attention of the world's leading chemists and physicists, and they have made rapid strides within a generation in elucidating the molecular relations of the elements of steel. They have isolated by ingenious methods many well defined chemical compounds, such as the carbides, phosphides and sulphides of iron and manganese. It remained for an American, addressing one of the leading scientific societies of our country, to discourse upon carbides of phosphorus (not in our chemistry), carbide of silicon (carborundum) and carbide of sulphur (foul smelling, endothermic and a solvent for rubber) as constituents of steel. As he also sang the praises of imported wares, it may be that we are behind the times over here and that these choice foreign products do contain such compounds. We have seen some American products that might be called "rotten," but they were not characterized by an appreciable odor of sulphide of carbon (CS_2).

ALLOTROPIC MODIFICATIONS.

The complexity of steel from a chemical standpoint is further increased by the allotropic character of iron, and by the fact that carbon and probably sulphur and

*Iron Age.

phosphorus may exist in several conditions or combinations. As iron is cooled from a molten condition, it has been discovered that at from one to three points on the thermometer, below its freezing point, cooling momentarily stops.

For carbonless iron these temperatures are designated as Ar_1—the ordinary "recalescent" point. It is believed by many that Ar_3 and Ar_2 temperatures indicate transition or critical changes in the nature of iron itself. In other words, that just as phosphorus may exist in two distinct forms, one yellow and one red, so the element iron is supposed to be acapable of existing in different physical conditions at different temperatures. At temperatures above Ar_2 we have the "gamma" iron of Osmond, nonmagnetic and a solvent for both elemental carbon and iron carbide. Between the Ar_3 and Ar_2 temperatures we have iron existing in its "beta" condition, nonmagnetic but not a solvent for free or combined carbon. Below Ar_2 iron is in its "alpha" condition, nonmagnetic but not a solvent for free or combined carbon. Below Ar_2 iron is in its "alpha" condition, magnetic but not a solvent for free carbon, but possibly a slight solvent for combined carbon. While some metallurgists do not accept this explanation of the significance of the critical temperatures and ranges, all concede that they do occur, and that other elements added to iron carbon alloys change, obliterate or modify the temperature ranges, and it is just on account of this that different steels require different temperatures for forging, annealing and hardening.

TYPES OF ALLOY STEELS.

So much for the nature of alloy steels, and now a few suggestions as to their treatment and a few words as to the various kinds of alloys.

The constitution of these products, chemical and physical, for generations remained unknown and a matter of speculation. Tremendous progress has been made of late years in clearing up a few of the obscure points. It was the writer's good fortune to have been initiated into these mysteries by the late Prof. Sir William Roberts-Austen and by Prof. H. M. Howe, recognized pioneers and leaders in the task of making a science of the ancient art of metallurgy.

The first commercial alloy steel, at least the first to make a great name for himself, was Mushet's air hardening tool steel. The next alloys to attract attention were of the structural types, and may be said to have had a public introduction when Riley presented a paper to the Iron and Steel Institute of Great Britain upon iron and nickel.

Shortly afterward Hadfield's famous manganese steel was proclaimed and later he has produced many valuable products, especially in the line of armour and projectile steels. Along with the making of the new products has proceeded the study of their properties and methods of heat treatment. To-day a host of devotees, skilled in the science of heat treatment, apply their knowledge to the manufacture of tools, automobile parts and machinery to produce results never dreamed of a generation ago.

The principal types of alloy steels are those used (1) for materials of war, (2) for tools and (3) for materials of construction. The first are mainly alloys of nickel, chromium and tungsten or combinations of these elements. The makers of these alloys also conduct the heat treatments and guard their methods jealously. Alloy tool steels include air hardenening and high speed steels together with a large number of steels of the "special" class containing relatively small amounts of alloying elements, giving them special characteristics and fitness for particular and severe requirements. One product of this class is remarkable in that it undergoes no change in form upon hardening; moreover, it hardens in oil sufficiently to make a remarkably good tap, cutter or die.

NICKEL, CHROME-NICKEL AND CHROME-VANADIUM STEELS.

The alloys receiving most attention to-day are those of the third class—namely, materials of construction, and particularly the automobile steels. These are in general of three kinds—nickel steels, chrome nickel steels and chrome vanadium steels. Many different analyses are made under each class. The difficulty of producing sound nickel steel, free from pipes and seams, has injured the reputation of this most useful alloy with many users. This difficulty has been greater than need be because certain steel companies have mistaken a quality proposition for a tonnage proposition, and have offered nickel steel at absurdly low prices, wholly inconsistent with uniformity of analysis, careful workmanship and inspection. Discriminating users recognize this fact and are willing to pay a premium for the product of certain mills, because their steels are made in smaller tonnages and units, are more carefully handled from start to finish, are worked under hammers rather than in blooming mills, are made from purer materials and carefully inspected when done. The best is none too good for constructing the vital parts of an automobile, and when a concern has secured the best that the market affords, it has but taken the first step in producing good parts. Next come the forging and machining and the heat treatment, for better or worse. It is money wasted to buy good alloys unless one is willing to study them sufficiently to know how to treat them and then supply adequate facilities for so doing.

THE NEED OF APPARATUS FOR TESTING.

It is not to be expected that small users will install complete testing laboratories, but a few dollars invested in having occasional tests made will be well spent. There are, however, many large concerns that could and should spend, say, $5,000, for which it is believed the whole or a large part of the following equipment could be obtained: The ordinary tensile machine, a microscope, electrical or gas furnaces capable of fine regulation, a good pyrometer, preferably

recording. The tensile machine can also be used for making Brinnell hardness tests, spring deflection tests, etc. In addition to these some form of drop testing machine, such as the Fremont, will be found valuable; a vibratory or repetitive impact test is nowadays considered a necessity, while cold bending and torsion apparatus is useful. This equipment will be of small use, unless a thoroughly good man is put in charge—a careful, conscientious man of sound judgment.

This man should direct the heating operations in the factory; he should construct furnaces which heat uniformly, and he should exercise eternal vigilance in keeping the pyrometric installations up to par.

It is a remarkable watch that never requires adjustment or repairs; a little attention is devoted to the up-keep of all apparatus and machinery, but the pyrometer is supposed to take care of itself. Too frequently it is never questioned, never calibrated. The best pyrometer of the thermocouple type should be looked over at stated intervals, especially if in constant use. Protecting tubes should be frequently examined and renewed, and electrical contacts looked over. Occasionally check up the millivoltmeter. Unfortunately there are many pyrometers of the thermocouple type on the market which cannot be watched too closely. Quite recently I visited two concerns where they were hardening the same grade of steel and doing it well. I asked each concern what temperature it was using. One said 1,300 degrees F. and the other 1,700 degrees F. The actual temperature in both cases was probably 1,500 degrees F. Another so-called cheap pyrometer that I tested departed from the truth over 100 degrees in a month and another was 50 degrees off when installed. In a lot of six couples tested after being in use some time, three were all right and three all wrong and by varying amounts. If you are going to use pyrometers by all means see that you have good ones and then see that they are systematically tested.

Many people buy high priced alloy steels and get no better results from them than could be had from a carbon steel properly handled. If you cannot afford a good pyrometer stick to the trained eye of a skilled man; and if you have a good pyrometer employ a skilled man, anyway, and consider the pyrometer as an aid. With it you can at least give orders in temperatures rather than in heat colors, and the laboratory and works can meet on an intelligent basis. Pyrometers, like "smoke consumers," are all right if carefully watched and intelligently used. Too often both fail after about 30 days' use.

A CALL FOR CONSERVATISM.

The writer has probably devoted as much attention to the literature and fabrication of alloy steels as any reader of this contribution, and the more experiments and the more practical results he observes the more strongly he believes in the wholesomeness of straight nickel steel and certain of the chrome vanadium types. The ease with which these can be machined, especially in the cold drawn condition, is not least among their advantages. While not wishing to appear behind the times and recognizing the good there is in other classes of alloys, the writer believes the matter has been overdone and new products have not in all cases been sufficiently tried out before being put into actual commercial service. Some discrimination should be used in selling alloys where the user is not equipped to get his money's worth from the material. Heat treatment operations depend upon a solid scientific basis. And by this is not meant that steel essentially of inferior quality can be made to pass muster by heat treatment.

NOTEWORTHY RESULT OF HEAT TREATMENT.

On the other hand, however, it might be said that alloy steel in its so-called natural state, as it comes from the rolls, hammer or drop forge, is almost unfit for automobile construction. Steel which depends upon alloys for a high elastic limit in its natural condition will have much less elongation than the same steel oil tempered and annealed. For example, a chrome steel gave in its rolled condition 158 000 lbs. elastic limit and 5 per cent elongation, with 0.4 per cent elongation and 52 per cent reduction of area. In other words, the material was transformed from brittle to tough from treacherous to safe, without materially affecting its elastic limit. A nickel steel similarly treated had its elastic limit raised 20 per cent, with the reduction in area improved and its elongation unchanged.

We have tried to give some insight into the construction of alloy steels, the problems involved, the means by which they may be attacked, and some precautions to be observed in the commercial handling of these valuable products. If anything here written shall increase the respect of the user of alloys for the materials he handles and for the men who produce them, and better still, if anything herein shall stimulate a greater desire in the user to test and study alloy steel more carefully, and strive for practical results somewhat approaching the maximum potentialities of his materials, the writer's efforts will not have been in vain.

The values of the iron and steel imports into the Australian Commonwealth during 1909 were as follows: Bars, rods, girders, joints, etc., £902,000, as compared with £990,000 in 1908 and £1,071,000 in 1907; galvanized plates and sheets, £1,442,000 as compared with £1,128,000 in 1908, and £1,356,000 in 1907; tinplates, $285,000, as compared with £285,000 in 1908 and £240,000 in 1907. Agricultural machinery to the value of £478,000 was imported last year, as against £431,000 in 1908, and £410,000 in 1907. Other machinery imports were valued at £2,881,000, as compared with £2,771,000 in 1908, and £2,760,000 in 1907. The exports from the Commonwealth during last year included coal to the value of £838,000, as against £1,340,000 in 1908, and £1,200,000 in 1907.

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NOTES AND COMMENTS.

THE YOUNG MAN IN CHEMICAL ENGINEERING.

Young men in our technical schools have in the past rather fought shy of the courses in chemical engineering. We find in all of our great technical schools where this course is given that the classes in chemical engineering are very much smaller than those in the other engineering courses. The course in chemical engineering is a comparatively recent one. The average young man going to a technical school has no acquaintance with chemical engineers and no knowledge of the work required of a chemical engineer or the possibilities held out, both in the way of remuneration and advancement in commercial life. The older members of the profession have been in rather close competition with the man trained as a chemist and we have as yet not drawn a very sharp distinction between the chemist and the chemical engineer. Many of our young men graduating in chemical engineering feel that they must commence their work as an analyst in a chemical laboratory. There may be some question as to the wisdom of this, providing they, as most of them do, wish to make their way ultimately into the manufacturing part of the plant. Dr. T. B. Wagner in an address some time ago defined the work of the chemical engineer and pointed out in a very clear manner the way in which the young man can make his way from the laboratory to a responsible position in the manufacturing department. The following is abstracted from his address.

"The young man, after leaving college, must make up his mind that in order to achieve success or distinction, it is necessary for him to acquire experience which is of value to himself and to his employer. To do this, he must start at the very bottom of the ladder; he must not attempt to climb to the top all at once. You will see, therefore, that it is anything but a "get-rich-quick" method; on the contrary, only those can expect to win out who approach their task with deliberation and a great degree of earnestness, patience and perseverance. First of all, the young chemist must learn to master the details of the laboratory work—his immediate sphere. This experience and knowledge will give him the key to the situation; it is the foundation of his work and of his future. This is where he acquires, if I may so term it, the philosophy of the business. In due course of time he will acquire a knowledge of the various operations involved in manufacturing divers products; he must learn the details of the necessary machinery, their operations, their objects, their efficiency, their defects, etc. He will now begin to realize that when he left college he was by no means through with his studies; in fact, it will begin to dawn upon him that the real studies of life have only commenced. Factory work is perhaps the hardest and perhaps the most responsible for a chemist. An accurate chemist will not find the laboratory task a particularly trying one. Problems, however, connected with actual production of manufactured goods place a greater responsibility upon him. So we now come to the point where the young factory chemist must lay in a store of mechanical knowledge, if he has not been fortunate enough to get a mechanical training while at college. In the former case, it may prove to him a hard task, because he has no foundation to build on. Therefore, he must once more become a student and a hard-working student at that. After he has acquired this knowledge, he will be ready to assume the duties of a foreman or assistant superintendent and, in due course of time, those of a superintendent.

"He must now begin to branch out and leave the narrow confines of his factory work; he must look around and study the latest improvements pertaining to his particular industry. He must study the labor question, which is identical with mechanical advances which tend to do away with manual labor; he must study the latest developments in industrial economy, the latest progress in overcoming industrial wastes; in brief, he must keep abreast of the times. Having devoted himself to this line of work, he will gradually have become a master in his line, so far as its technical side is concerned. However, to truly master the situation, to understand the needs of his industry and to fully understand and appreciate the possibilities of its evolution, it is necessary that he should study closely the commercial side of the business. When I speak of the commercial side, I do not mean to refer to the mere routine and detail of commercial work. I wish to apply this name in its broadest sense. Of course, he will not find any text books to guide him and furnish him enlightenment. He must come in contact with the men who represent the industry, who extend its commercial spheres and who build higher upon the foundation which may have originated with the chemist. As long as he was a chemist in the laboratory he found himself greatly handicapped, because he was not in a position to know the requirements of his industry, he was not in a position to promote it, and if he were, he would not know how to accomplish it. Nor is the factory man in a much better position, because the daily routine taxes him practically to the limit, but having rounded out his own process of evolution by graduating from the laboratory to the factory and from the factory possibly into an executive position or

administrative position, he now is enabled to fulfill the expectations which were placed upon him when he entered the industry. He now may become a creative force in his particular industry. To be this, however, he must exercise the power of his own individuality, so that his counsel will be sought in the administration of the affairs of his industry. In fact, a greater value will be placed upon his counsel than on that of the purely commercial man or the purely technical man. You may think perhaps that men who have accomplished this are the exception, but we only have to look over the long list of illustrious names to prove that such evolutions can be made the rule and not the exception. Let me point out to you the great aniline industry of Germany, whose affairs to-day are directed by chemists such as Dr. Brunck, Professor Duisberg, Dr. Bayer, Dr. Bruening, Dr. von Martius and others, or the great alkali industry of England, at whose head for many years Ludwig Mond has shown himself as a master mind, a man of affairs. In our own country are innumerable instances, which I could quote and which I should quote, if time would permit. Briefly, however, I wish to refer to one of the leading chemical industries of this country, the General Chemical Company, which is directed by Mr. Nichols, who is a graduate of Columbia University. Associated with him for many years has been Mr. Herreshoff, whose name I know is familiar to you. Take our great iron and steel industries, the men at their heads to-day are largely men with a chemical training."

Cooperative Books.

In a circular letter to the members of the American Institute of Chemical Engineers, Dr. Chas. F. McKenna, President of the Institute, holds forth as one of the possible future purposes of the Institute the compilation of an authoritative work on Chemical Engineering. If the Institute did nothing more than issue this volume, even though it took some years to do so, it would still have contributed work of inestimable value to the manufacturing chemist and justified its existence.

It is now generally conceded that the only way in which a reliable work covering the whole field of applied chemistry could be written is by the united efforts of many men, each an expert in his field. Applied chemistry has grown so broad and has become so intricate that it is no longer a subject which one man can master. The vast majority of our text books on Industrial Chemistry are full of errors and of descriptions of obsolete processes and machinery. Of reliable works on Chemical Engineering there are none treating of American practice. The literature of applied chemistry has never kept pace with its developments and in every industry numerous processes and appliances are in use of which no description is to be found in even current technical literature.

The plan of co-operative bookmaking has been urged several times in these columns and we believe that books upon Chemical Engineering and Industrial Chemistry which aim to cover the whole field will in future be gotten out after this method. A text book of Industrial Chemistry in which the various chapters are written by experts is at the present time in course of preparation, and this book should prove authoritative if nothing more. The objection which might possibly be raised to such a plan for a text book is that the material would probably not be presented in that logical way which is desired in a text book. For the preparation of authoritative works of reference, however, this method cannot be excelled, and the preparation of a large reference work or encyclopedia by a large number of experts would prove a basis from which the teacher might draw reliable information for the preparation of a smaller book for the use of his classes.

We trust that Dr. McKenna's plan will be followed out by the Institute and also that sooner or later some enterprising publisher will be willing to invest the necessary capital to publish a large work on Industrial Chemistry. Books giving only popular descriptions of processes are not needed. What is actually required by the chemist who has occasion to look up information about manufacturing methods, are detailed statements as to processes employed, cost of plant and production, nature and occurrence of the raw materials, etc.—information which the text book of the past has failed to throw any light upon.

What the industrial chemist of today needs is not only information as to how to do a thing, but also as to the cost of doing it and how extensive a plant is needed to carry out the process. In short, today Industrial Chemistry is a problem in economics as well as one of chemical reactions, and the dollar mark is interspersed with the chemical symbols of the equation. The successful works of technical chemistry whether dealing with general or specific subjects must give cost data. Such information only the expert possesses—hence the necessity of co-operation in the preparation of books of a general nature.

Plans of the Department of Mines of the Canadian Government for the Coming Year.

The fuel testing plant at Ottawa is to be operated, under the direction of Mr. B. F. Haanel, for the purpose of experimentation and demonstration. A second producer, suitable for lignite and bituminous coal is to be installed at the plant.

The Government peat bog at Alfred is to be operated for a period of about three months to demonstrate the latest process of manufacturing air dried peat. Several thousand tons will be produced during the present season. Part of the peat fuel produced will be shipped to Ottawa for use in the peat-gas producer plant now installed, and part will be sold in the neighborhood for domestic use.

The investigation of peat bogs in Canada, to ascertain their extent and to determine the quality and

quantity of peat available, will be continued by Mr. A. Anrep, after the operating plant at Alfred is closed down for the season.

Commercial processes for utilizing the sulphur content of pyrite ores are to be investigated with the object of preparing a special bulletin on the subject.

Pyrite burning is of special importance at the present time with respect both to the sulphite pulp industry and to the preparation of mineral fertilizers. This work is to be undertaken by Dr. A. W. G. Wilson in the autumn.

The investigation of the molybdenum deposits of Canada will be continued by Dr. T. L. Walker for the purpose of completing and publishing a monograph on the subject.

A special report on the building and ornamental stones of Ontario is to be prepared by Dr. Wm. A. Parks. This report is to be the first of a series of monographs on the building materials of Canada.

A second edition of the monograph on mica, for which there is a constant demand, is to be prepared by Mr. Hugh de Schmidt.

An ore-dressing plant for experimental investigation into methods of concentrating certain iron ores is to be installed at the testing plant in Ottwa by Mr. G. C. Mackenzie.

Officers of the division of mineral resources and statistics will visit mining districts in various parts of the Dominion for the purpose of collecting statistics of mineral production, and of securing information of general interest relating to the mining industry, including a record of new and recent developments, and data as to character of ores and products, prices, markets, and demand for various mineral products.

A special expert is to be engaged to investigate metallurgical problems of economic importance. The plant of the School of Mines at Kingston has been placed at the service of the Mines Branch for this purpose.

CLOTH FROM WOOD.

A recently-invented French process for the manufacture of cloth out of spruce wood is being investigated by a number of New England cotton experts. The cloth is said to resemble the finest mercerized cotton in texture and sheen, while it takes on dyes more brilliantly in the bleaching and finishing than does the real cotton fibre. The cost of the new fabric will be much below that of cotton cloth. In fact, it is stated that the finished wood pulp cloth will be cheaper than the raw cotton in bales.

The first step is to reduce the spruce wood to cellulose, much after the method used in the initial steps of making pulp for paper manufacture. The reason that spruce is preferred is because of its lack of color, which, of course, is a feature in bleaching and dyeing the finished cloth.

After the wood is reduced to cellulose, this liquid is then pressed out into threads by two different methods. For coarse fibre the pulp is pressed through perforated steel plates, and as it hardens when it strikes the air it may be wound on spools or drums in any lengths desired. For the finer fibres the holes through which the wool cellulose is pressed are in glass tubes, drawn out to very small orifices. When made from spruce this fibre is almost white, and it may then be bleached before being dyed.

It has been brought out also that this wood pulp cloth or "soyeuse," to give it the French name, will resist boiling water or caustic potash solutions for several minutes without change. Also it burns no more rapidly than does cotton, and this is a most important point in artificially-produced textiles. A substitute for silk that is much used in the cheaper grades of ties is already made from wood pulp treated after a different process from the French method of making the cotton substitutes. But this imitation silk is highly combustible. It is extreme combustibility that has been a charge against imitation silk, but to the new substitute for cotton there is no such objection.

RECENT PATENTS.

The following recent patents have been reported for the Chemical Engineer by C. L. Parker, solicitor of chemical patents, Washington, D. C.

953,798. *Safety-Powder for Blasting.* Gershom M. Peters, Cincinnati, and Milton F. Lindsley, Kings Mills, Ohio. April 5, 1910.

953,946. Process of *Rendering Bran Digestible.* Dittmar Finkler, Bonn, Germany, April 5, 1910.

954,080. Process of *Producing Hydrocyanic Acid.* Otto Dieffenback and Wilhelm Moldenhauer, Darmstadt, Germany, April 5, 1910.

This is a process of producing hydrocyanic acid by synthesis by means of highly heated coal, hydrogen and atmospheric nitrogen, consisting in passing over the coal a mixture of hydrogen and nitrogen containing not more than forty per cent of carbon oxid.

954,185. Method of *Making Manganese Steel.* Henry D. Hibbard, Plainfield, N. J., April 5, 1910.

954,188. Process of *Making Manganese Steel.* Henry M. Howe, Bedford, N. Y., April 5, 1910.

954,209. *Pulp.* Charles W. Roberts, Lockport, N. Y., April 5, 1910.

954,263. *Treating Arsenid Ores.* Frederic P. Dewey, Washton, D. C., April 5, 1910.

The process consists in subjecting the ores to an arsenate roast, treating the roasted ore with acid and recovering the metals from the solution.

954,486. *Saponaceous Compound.* Eduard Weiss, Weiden, Germany, April 12, 1910.

954,666. *Varnish.* Leo H. Baekeland, Yonkers, N. Y., April 12, 1910.

954,692. *Composition of Matter for Concrete.* Henry D. Phillips, Indianapolis, Ind., April 12, 1910.

954,767. *Composition of Matter Containing Oxids of Aluminum and Titanium.* Lewis E. Saunders, Niagara Falls, N. Y., April 12, 1910.

954,889. Process of *Malting.* Joseph Schneible, Chicago, Ill., April 12, 1910.

955,082. *Cellulose Formate.* Sigmund von Kapff, Aachen, Germany, April 12, 1910.

This is a process of making cellulose formate which consists in dissolving cellulose as described in a solution of zinc chlorid in formic acid.

955,318. *Treatment of Ores Bearing Precious Metals.* John C. Clancy, New York, N. Y., April 19, 1910.

955,762. Process for *Coating Metal Objects.* Bernard Hemann, Belleville, Ill., April 19, 1910.

955,762. *Preserving Wood.* William B. Chisholm, Charleston, S. C., April 19, 1910.

955,811. Method of *Hydrating Lime.* Lynn T. Leet, Reading, Pa., April 19, 1910.

955,898. Process of *Separating Pulp Fibers from Pigments, Size, Filling and Other Impurities.* Bismarck W. Petsche, Yonkers, N. Y., April 26, 1910.

955,953. *Plaster Composition.* Carleton Ellis, Larchmont, N. Y., April 26, 1910.

956,120. Process of *Producing Manganates, Permanganates, Halogens and Hydroxids.* Florentine J. Machalske, Chicago, Ill., April 26, 1910.

956,184. Process of *Obtaining Sulfurous Acid from Acid Sludge.* Gustav Schildhaus and Constantin Condrea, Campina, Roumania, April 26, 1910.

This is a process of producing sulfurous acid, liquid hydrocarbon, and coke from acid tar or sludge which consists in distilling said acid tar and introducing a stream of air into the retort during distillation, condensing the liquid hydrocarbons contained in the distillation products, washing the remaining sulfurous acid gas, and continuously removing the coke from the retort.

956,246. *Dehydrating Milk.* Thomas L. White and Alfred P. Elten, New York, N. Y., April 26, 1910.

956,303. Process of *Purifying Alkaline Chlorids.* Charles H. Dasher, Oakland, Cal., April 26, 1910.

956,320. *Paint or Varnish Remover.* Carleton Ellis White Plains, N. Y., April 26, 1910.

The composition comprises approximately acetal gallons, acetone 10 gallons, bensol 10 gallons, 7 pounds ceresin and 15 pounds of cork dust.

956,371. Method of *Distilling Coal.* Heinrich Koppers, Essen on the Ruhr, Germany, April 26, 1910.

956,381. Process of *Treating Ores.* Alfred A. Lockwood and Marcus R. A. Samuel, London, England, April 26, 1910.

955,409. Method of *Vulcanizing Rubber.* Harry F. Pendleton, Brooklyn, N. Y., April 26, 1910.

956,734. Process of *Manufacturing Methane or of Mixtures of Methane and Hydrogen.* Paul Sabatier, Toulouse, France, May 3, 1910.

The process consists in passing steam over carbon confined in a retort maintained at a constant temperature to produce water-gas of constant composition, then removing the carbon dioxid from the resulting gaseous product and passing the carbon dioxid free gases over heated nickel.

956,763. Process of *Separating Metals in Solution.* Walter S. Gates and Herbert H. Dow, Midland, Michigan. May 3, 1910.

956,764. Process of *Producing Lithographic Printing Plates.* William Gerb, Berlin, Germany. May 3, 1910.

956,773. Process of *Treating Ores and Carboniferous Earths.* Alfred A. Lockwood, London, England. May 3, 1910.

956,800. Process of *Treating Metallic Slimes.* James Dunstone, Dollar Bay, Michigan. May 3, 1910.

The process consists in agitating copper slimes in the presence of an emulsion of oil, an aqueous solution of sodium nitrate, and an acid adapted to decompose the sodium nitrate, and collecting the portion floated.

956,977. Process of *Hydrating Lime.* William H. Kemler, Ashland, Kentucky. May 3, 1910.

957,006. Method of and *Apparatus for Producing Gas.* Edwin E. Slack, Pittsburg, Pa. May 3, 1910.

957,157. Process for *Cleaning Iron Ores.* Edward F. Goltra, St. Louis, Missouri. May 3, 1910.

957,231. Process of *Treating Impure Copper Matte and Ores.* Herman Maschmeyer, Hoboken, near Antwerp, Belgium. May 10, 1910.

957,295. Process of *Recovering Potash Salts.* Augusto Alberti, Rome, Italy. May 10, 1910.

This is a process of extracting potassium salts from the refuse liquor of the manufacture of tartaric acid, which consists in oxidizing the organic substances contained therein by adding to said liquor substances capable of developing hypochlorous acid, concentrating the purified mother-lye in a vacuum and crystallizing out the potassium salts.

957,307. *Explosive.* Conrad P. H. Claessen, Berlin, Germany. May 10, 1910.

957,352. *Moving Sign.* William W. Liles, St. Louis, Mo. May 10, 1910.

957,495. Process of *Producing Rubber.* Henry O. Chute and Frank L. Randel, New York, N. Y. May 10, 1910.

This is a process of preparing rubber by designating a crude vegetable material of the character described, containing rubber by treatment with a volatile solvent, and thereafter separating the rubber from the remaining impurities.

957,706. Process of *Making Hardened Steel.* Hector De Nolly St. Chammond, France. May 10, 1910.

957,754. Process of *Making Aluminum Flourid and Other Aluminum Compounds.* Philip A. Emanuel, Aiken, S. C. May 10, 1910.

957,761. Process of *Making Sodium Sulfite and Ammonium Chlorid.* Richard Friedrich, Glosa, near Chemnitz, Germany, and Friedrich Hirsch, Vienna, Austra-Hungary. May 10, 1910.

957,843. Process of *Making Ammonia.* Carl Bosch, Ludwigshafen-on-the-Rhine, Germany. May 10, 1910.

957,909. Compound for *Smoothing and Polishing Articles and Parts.* Winslow R. Parsons, Chicago, Ill. May 17, 1910.

958,084. *Manufacture of Silica Bricks, Ganister, and Other Refractory Materials.* Harry Brearley and Francis C. Moorwood, Sheffield, England. May 17, 1910.

958,177. Process of *Detinning.* Charles J. Reed, Philadelphia, Pa. May 17, 1910.

The process consists in detinning tinned iron scrap by mixing it with a subdivided foreign body, heating and agitating the mass, mechanically separating the finely divided products from the scrap and subsequently removing the tin as a gaseous compound.

958,180. Method of *Producing Tantalum.* Johannes Schilling, Halensee, near Berlin, Germany. May 17, 1910.

958,184. Process for *Quenching Coke.* Eduard Schulte, New York, N. Y. May 17, 1910.

958,652. Method of *Regenerating Carbon-Filament Electric Incandescent Lamps.* Ernst A. Kruger, Sechausen, Altmark, Germany, May 17, 1910.

This is a method of regenerating used carbon filament electric incandescent lamps, consisting in opening the lamp, in burning off the carbon deposited on the interior surface of the same, in evacuating the lamp, in connecting the evacuated lamp with a vessel containing a measured quantity of a pure hydrocarbon, in flashing the filament in the lamp, in evacuating the lamp and in sealing up the lamp.

958,820. Process for the *Treatment of Oils.* Joseph H. Parker, Los Angeles, Cal. May 24, 1910.

958,851. Process of *Reducing Refractory Ores, Particularly Oxids and Sulfids.* Gibeon Boericks, Philadelphia, Pa. May 24, 1910.

This is a process of reducing refractory ores which consists in subjecting the said ores to heat in the presence of some reducing compound containing manganese, and another reducing agent of such character that the two agents will be in their oxidized form flux the mass.

958,893. Composition of *Hydrated Sodium Carbonate and Sodium Tannate.* William E. Ridenour, Philadelphia, Pa. May 24, 1910.

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ENGLISH PRACTICE IN THE DESIGNING AND WORKING OF A MODERN REFUSE DESTRUCTOR.

In the May, 1910, issue of THE CHEMICAL ENGINEER, in an article on the Chemical Utilization of Municipal Waste, the design and operation of a plant for the reduction of garbage and street sweepings was considered, largely from the American point of view. Data on the English practice in the designing and working of a modern refuse destructor have been well set forth in a paper read last year before the Incorporated Association of Municipal and County Engineers by Mr. William F. Loveday, Borough Surveyor, Stoke Newington, England. Mr. Loveday's paper, practically in full, follows:

The general trend of development and progress in destructor practice, more particularly during the past two years, has been on the following lines:

(1) The amelioration of the conditions for the workman in the destructor house.

(2) The introduction of details in construction which ensure fairly high temperatures and a normal ruling condition in the furnace proper.

More efficient means have been introduced for the ventilation of the destructor house, and this is a step which is undoubtedly in the right direction. It is well known that, in any plant that is not strictly up to date, a visit to a destructor plant is synonymous with dust, and the experience could never be looked forward to with anything but feelings of dismay and prospective discomfort. In up-to-date plants ventilating ducts are provided, and the house is so constructed as to permit of the air being renewed from four to five times per hour. The vitiated air is withdrawn through these ducts and led to the fan inlet, from whence it is propelled to furnace ashpits.

In this direction, also, means have been introduced for facilitating the clinkering of the fires. This is by common consent the most laborious operation in the whole cycle in destructor working, and anything that can render easier the clinkering of the fires would be hailed by the fireman, at any rate, with the utmost satisfaction.

Taper castings have been introduced which form a line of cleavage between and in the grates, and much facilitate the breaking up of the fires before withdrawal.

Although there are several different firms who specialize in destructors, yet there are practically only two groups or types, namely, the "single cell" and "continuous grate."

These may be again subdivided or classified by the method adopted in feeding the refuse into the furnace, namely—

(1) Top Feed: In which the refuse is fed in through the top directly on to the fire or on to a drying or desiccating hearth and then pulled forward on to the firebars.

(2) Back Feed: In which the refuse is fed in through an opening at the back and clinkered from the front.

(3) Front Feed: In which the refuse is fed in through the front and clinkered from the same opening.

With regard to the top feed, although possibly there is considerably less handling, yet there are grave objections so far as obtaining good results from the combustion and evaporization point of view. Should a load arrive which is either very wet or contains an unusual quantity of tins, earthenware, bottles, or other incombustible matter, it must of necessity go into a particular cell, with the consequent effect of reducing very considerably the temperature in that cell. Again, the refuse has to be pulled forward on to the bars, and it is difficult to get an even thickness and uniform density over the grate when handling long and heavy firing tools over a hot fire, with the result that the forced draft will take the line of least resistance and will escape through the thin parts, to the detriment of the thicker portion which most requires its aid for a complete and perfect combustion. The front or back feed enables the stoker to apply the refuse more evenly and with more discretion, and although the method of charging with the shovel by hand has been described as putting it on by the spoonful, yet to obtain the highest efficiency the makers of mechanical stokers have been employing this method of small quantities at a time with the best results.

In the single-cell type of destructor the cell is an isolated furnace, having an opening through which the refuse is delivered on to the grate bars, and an opening at either the back or front for the outlet of the products of combustion. These latter pass into a main flue which is common to a number of cells built in parallel.

The cell being isolated, the process of combustion must go on unaided by any adjoining fire, and the

temperature obtained depends entirely on the quality of the refuse with which it is charged.

There is a type of furnace which consists of two cells having a boiler between, so that the gases evolved in each cell pass immediately under the boiler, and are, consequently, cooled before complete combustion has taken place. It has the further disadvantage that, at the time of clinkering, the admission of cold air must adversely affect the boiler, having regard to the fact that the boiler is in such close proximity to the cell.

The continuous grate is, as its name implies, a number of grates in line, each having a separate ashpit, but with the space above the firebars communicating; that is to say, the gas is passed the whole length of the series of grates into a combustion chamber, and from thence to the boiler. A charge put on any one grate must naturally receive a large amount of assistance from the other fires, and the time taken in the initial ignition and combustion must therefore be considerably less than in the single-cell type.

The great fluctuation of temperature in the single cell affects the firebrick lining very seriously, due to expansion and contraction. This is taking place between each operation of clinkering, about every two hours. This fluctuation is reduced to a minimum in the continuous grate, for the reason that there are always other fires in the furnace at the time of clinkering any one fire.

There can be no doubt, however, that the continuous-grate type of furnace construction is being looked upon with much greater favor, and a few words might be said with regard to the leading features which characterize the best-known systems of this type.

It may be laid down that the following are absolutely essential features in the design of any furnace that can reasonably fulfill the primary objects for which it exists, viz. the complete destruction by fire of obnoxious matter without nuisance, and general provision for the utilization of the heat generated in the process:

(1) A continuous furnace chamber with the grate laid off in sections, each section independently controlled and so operated that it is a complement of the others.

(2) Provision for heating and regulating the air-supply for the necessary forced draught.

(3) A combustion or dust settling chamber.

(4) Steam generator.

The rate of burning in a continuous grate is higher than in an isolated cell. This rate of burning is materially increased if the arch over the grate is undulating, which causes the gases in one fire to be deflected on to the next, and again from that on to a third. The gases distilled from the green or newly-charged refuse must be more thoroughly cremated when brought into contact with other fires, than can be the case when going direct from an isolated cell to the boiler. It is obvious therefore that, combustion being more perfect, a higher as well as a more regular temperature is attained, and therefore a higher rate of burning.

As the result of careful observation the author has found that the ratio of burning on each grate on a three-grate unit is as 3, 4, and 5. On the grate furthest from the combustion chamber the rate of burning was 55.21 lbs. per sq. ft. of grate area per hour; on the middle grate, 74.6 lbs., and on the grate next the combustion chamber 89.6 lbs., which gives an average of 73 lbs. per sq. ft. of grate area per hour over the whole area.

In the cycle of operations which takes place after the delivery of the refuse into the storage bunker there are three distinct stages, in each of which the features embodied in the furnace design play an important part. These stages are:

(1) The charging stage.

(2) The burning stage.

(3) The clinkering stage.

With regard to (1) a storage hopper or bunker is provided. This is placed in a position convenient of access for the firemen, and just opposite the charging door to the furnaces. It is usual to provide for approximately half a day's supply of refuse in the bunker, but, of course, the hours of collection in general determine the amount of storage that should be provided for.

The refuse is shoveled direct from the hopper and spread over the furnace grate in one operation by the fireman.

Stage 2. At this stage the utility of the continuous furnace chamber and sectional grates is at once put into effect, as also No. 2 of the essential features in the furnace design, viz., the heated air-supply. Whenever the material is charged it is ignited by the flame from the adjoining fires, and the temperature of the furnace chamber is further increased by the forced-draft air-supply, which is heated by means of the air-heater or regenerator. Control and regulation of the air-supply are of the utmost importance, and for this purpose a special valve is provided which can be manipulated and adjusted to meet all conditions.

Until recently the great object of the destructor furnace designer, viz. the maintenance of a uniform and normal ruling temperature in the furnace chamber, could not be attained, the chief difficulty being reached at the third stage in the process of clinkering the fires, when an inrush of cold air inevitably reduces the temperature of the chamber. By an ingenious device it is now possible to automatically and continuously control the conditions determining the efficiency of combustion in the destructor furnace. This apparatus is an entirely new feature in destructor practice, and has been installed on the plant just put to work in New York, and has been an unqualified success.

House refuse ordinarily contains a high percentage of vegetable matter, which consists of upwards of 70% of moisture. Under these circumstances a steam jet as a means of supplying forced draft does not

strike one as being as desirable as it would be adding air saturated with steam to an already heavily-charged moist fuel. The better method, therefore, of supplying forced draft or a pressure of air in the ashpit would be by fan. It is eminently desirable, however, that the air should be heated. This can be obtained from the waste gases after leaving the boiler by means of an air-heater through which the gases pass down a series of tubes, whilst on the outside of the tubes the air is driven from the fan into the ashpit.

There is thus a good exchange going on, the waste gases are made to give up a large amount of their heat to heating the air for forced draft. The heated air on entering the furnace absorbs whatever moisture there may be in the fuel, thereby saving the fuel to that extent which it would otherwise have to give up in the absorption of its own moisture and thus adding increased calorific value to an otherwise poor fuel. This is therefore a very important feature to bear in mind, that heated air rapidly takes up moisture from the refuse and thus materially decreases the time taken for burning. It also is a well-known fact that air heated previously to being discharged into the furnace has the effect of increasing the temperature about twice the temperature of the air so delivered.

The advantage of heating the air may be expressed in terms of coal. Thus with using air at a temperature of 300° F. is approximately equivalent in effect to the addition of about 1 cwt. (112 lbs.) of coal to each ton of refuse.

The ventilation of the destructor house should not be from the inside to the ouside, but vice-versa. By this means any objectionable odor which may arise when the refuse is being delivered is not distributed to the surrounding neighborhood, as is the case when the ventilation is from the inside to the outside. The best means of ventilation is by means of an air duct constructed in the roof, communicating with the shaft supplying the air for forced draft for the furnaces. The air is drawn from every part of the house simultaneously, heated and passed through the furnaces, and as the only means of ingress for the fresh air should be at the openings at the ground level, this method ensures that the inside of the building is as fresh as it is possible to be.

Incidentally, the fan thus serves a double purpose, as it extracts the air from the destructor house and affords a good system of ventilation, and also the purpose for which it was originally intended, namely, the supply of forced draft.

Generally speaking, the following are features which should be absolutely insisted upon in any destructor installation:

(1) Cleanly operation, absolute freedom from nuisance to the neighborhood, and maximum comfort for workmen.

(2) Minimum capital cost, consideration being given to the value of the steam and clinker, and general efficiency.

(3) Low maintenance charges combined with low labor cost.

(4) The necessity for heating the air-supply has been more than ever demonstrated in recent years, and this can be most economically effected by placing the heater in the path of the waste gases just at the boiler outlet.

(5) Maximum evaporation.

(6) Regular steaming.

(7) Clinker of marketable quality.

The plant at Stoke Newington was erected by Messrs. Heenan & Froude, Ltd., of Manchester, and consists of two units of three grates each; each grate has an area of 25 sq. ft., and there is a separate ashpit to each grate. At the end of each unit is a large combustion chamber at right angles to the furnace. At right angles to this chamber and parallel with the furnaces are placed two Babcock & Wilcox water-tube boilers, each with a heating surface of 1,741 sq. ft.

At the end of the boilers are the air-heaters, and the gases after leaving these pass direct into the main flue. Each unit is provided with a separate fan and engine which are used as before described for ventilating the building and supplying the forced draught.

There is also a Worthington pump and an injector for filling the boilers. The plant is in duplicate, and each unit is worked every alternate week.

The floor of the destructor house is 10½ ft. below the tipping-floor, from which the refuse is shot into hoppers immediately in front of the furnaces.

The furnaces are of the front-feed type—that is, they are fed and clinkered from the same opening.

The average quantity of refuse received at the destruction in the summer is 30 long tons per day, and in the winter 45 tons per day. This is dealt with by two shifts of two men each. The number of hours worked by each shift is eight in the summer and ten in the winter.

During the two years the plant has been in operation there has not been a sufficient use for the steam generated, and the author is therefore unable to give a complete year's working of the results which could be obtained.

At present, beyond the small amount of steam required for the fan and the pump, there is a crusher engine of 15 HP., a disinfecting station, a small electric generating station with a dynamo of 77-KW. capacity, which is worked nightly at a load of 170 amperes and 515 volts, and 22 public slipper baths. The boilers are set to blow off at 160 lbs., and with the bye-pass damper partly open steam is constantly blowing off. During the winter six months, between the hours of 10 a. m. and 2 a. m., 2¼ lbs. of water are evaporated per lb. of refuse, and in the summer about 1½ lb. per lb. of refuse. In the summer work ceases at midnight.

The clinker is used for a large variety of purposes. During the last nine months the author has used some 1,000 long tons, which has resulted in a saving of 330l ($1,600) for ballast and sand.

The clinker has been used for concrete in foundations of walls, retaining walls, floors, roofs, concrete foundations for paved roads, both wood and granite, and also paving yards and footpaths. The divisions between the slipper baths were made of reinforced clinker concrete, 1½-in. thick, at a cost of 3s. 5¼d. (82 cts.) per sq. yd.

The cost for burning the refuse equals 7.3d. (14.6 cts.) per long ton. In addition there is the cost of cleaning the flues, amounting to 0.5d. (1 ct.) per ton. A fitter is employed about the premises, a portion of whose wages should be charged to the destructor. A boy on each shift is engaged for the purpose of picking out the tins from the refuse, which he pulls forward for the stokers, but this is no charge on the destructor, as the amount received for the tins equals the wages of the boys. The cost of disposing of the clinker in the first year amounted to 1961 ($950) but during the second year there will be no charge for this, as the sales and use to which the clinker has been put will probably result in a profit.

President Taft on July 7 announced that under the recent act of Congress providing for the Executive validation of withdrawals of public lands he had affirmed the withdrawal of 35,073,164 acres of coal land in Washington, Arizona, Utah, Colorado, North and South Dakota. Of this total 20,688,469 acres, comprising the withdrawals in North and South Dakota had not previously been authorized and are new. The remainder, 14,374,695 acres, were withdrawn under the previous administration, but were considered of doubtful title. The act of President Taft merely makes the previous withdrawals legal and will prevent any question being raised in the future. Of the lands already withdrawn by President Taft the water power sites cover a total of 1,454,499 acres. The phosphate lands withdrawn total 2,594,113 acres and the petroleum lands 447,119 acres.

The U. S. Consul at Algeria, reports that the Algerian production, exportation, and development of iron ore has increased steadily, putting the colony into the list of the considerable factors in the world's supply. The exportation during 1908 was 834,921 metric tons, of which 470,225 went to England, 242,242 to Holland, 47,564 to Germany, 41,856 to Austria-Hungary, and 7,775 to the United States. Of the three departments constituting northern Algeria, that of Constantine is most freely mineralized. The extension of the colony's existing railways and the construction of new ones in contemplation will soon bring about very heavy additions to the country's output of iron ore.

According to reports from Spokane, valuable deposits of tungsten manganese ore containing 70 per cent of tungsten have been found in the Blue Grouse six miles from Loon Lake, in the state of Washington

AN AVERAGING INSTRUMENT FOR CIRCULAR CHART RECORDS.

A certain class of recording instruments using circular charts having come into general use, there has developed a demand for a simple device to quickly determine the average of the record made on such charts, and the integral value for the whole twenty-four hours or for the time covered by the record.

This long-felt demand has been filled by the instrument illustrated herewith, which is based upon a fundamental plan as worked out and patented by Professor W. F. Durand of Stanford University, and is constructed in accordance with a novel design recently patented by Wm. H. Bristol, President of the Bristol Company.

The instrument can be applied for averaging records of any kind on circular charts having uniform graduations, as, for instance, records of watts, amperes, temperature, pressure, etc. Recording instruments equipped with circular charts are therefore made available for a number of applications for which it was previously thought necessary to use the instruments recording on straight lines or strip record charts. Recording differential pressure gauges are coming into use for measuring velocities and volumes of liquids, air or gas flowing in mains, and this integrating device will prove of value for quickly obtaining volumes of flow for any given period of time.

The simple construction of the instrument is shown in the accompanying illustration. A wooden base with a metal socket is provided for supporting and centering the chart. The socket holds a rotatable pin with a vertical slot at the top to receive the bar which carries the integrating tracer point and triangular support. The vertical groove in the rotatable pin allows the integrating wheel to roll on the chart with uniform pressure due to its own weight.

The integrating wheel is six inches in diameter, the rim being graduated into one hundred numbered equal spaces, and is fitted with a vernier, which makes it possible to easily read with the naked eye to one-tenth of one division on the integrating wheel. The wheel is of such large size it is not necessary to supply any counting device for the number of revolutions. The number of complete revolutions cannot be more than two, even for a record of maximum size on the large 12-in. charts.

To operate the instrument the thumb and forefinger of one hand are applied to the base of the triangular support, which is moved radially, so as to cause the tracer point to continually follow the record curve, while the chart is turned with the other hand.

By referring to a line plotted on a sheet of cross section paper furnished with the instrument, for the particular record curve that is to be measured, the total reading for the entire twenty-four hours may be taken off directly.

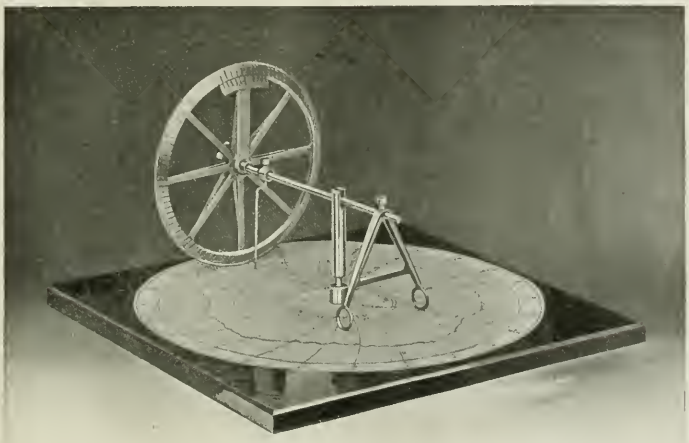
A full explanation of the theory upon which the operation of the instrument depends has been given by Professor Durand, in a paper presented at the New York meeting of the American Society of Mechanical Engineers in 1908. This may be briefly summarized as follows:

In applying the instrument it is necessary to have a uniform radial scale, from which it follows that equal increments in the length of the radius correspond to equal increments in the watts, amperes, temperature or whatever quantity is measured.

The integrating wheel being carried at right angles to shaft passing through the center does not turn and give a reading when the tracing point is moved on a straight radial line, but if the tracing point is made to follow a record, the integrating wheel will revolve and the amount of the revolution will correspond to the total of the circumferential elemental components of the record curve, the radial elemental components of the record having no turning effect on the integrating wheel.

As the length of the arcs of concentric circles for given angles or for the entire circumference are proportional to their radii, it is evident that the amount of turning of the integrating wheel, and the reading obtained thereon, will be proportional to the average radius of the record traced.

The instrument is adapted for integrating charts with either straight or curved radial time arcs. The correction necessary for radial time arcs which are curved may be made, after completely tracing the record, by returning the tracing point to a point on the chart having the same radius as the starting point, the movement of the tracing point being along an arc corresponding to the curved radial time arcs.



The Bristol-Durand Averaging Instrument.

SPECIFICATIONS OF THE U. S. NAVY DEPARTMENT FOR HIGH SPEED TOOL STEEL.

The steel shall be made by the crucible process, and shall be of uniform quality throughout, and shall be delivered in bars of commercial length, no short bars to be received, and shall be delivered annealed unless otherwise specified. The bars shall be free from all seams, cracks and other mechanical defects.

The steel shall be delivered and inspected in lots of not more than 5,000 pounds, unless otherwise specified, each lot containing its proper proportion of the sizes called for on the requisition.

The inspection shall be made at the navy yard, League Island, Pa., and shall be under the direction of an officer detailed for that duty by the commandant of the yard.

Each bar, up to and including a sectional area of 2¼ square inches shall be delivered with a test piece on one end about one and one-half times the larger dimension of the bar in length, nicked one-quarter through from each side while bar was hot, so that the test piece may be easily broken off. Larger bars to have coupon test piece forged on one end and nicked as stated above. The test piece must be stamped to match the number of the bar, and when forged down as a coupon must be about 1x1½ inches and about 3 inches long.

The test piece from each bar will be broken off and subjected to a higher heat test in an approved furnace, kept at a definite uniform temperature, which shall be as high as practicable. The test piece, when broken off the end of the bar, should show the fine grain which is characteristic of this class of high speed tool steel when properly made.

HIGH HEAT TEST.

The test piece shall be preheated slowly and thoroughly in a preheating furnace kept at a uniform temperature of about 1,550 degrees F. When thoroughly heated the test piece shall be quickly transferred to the high heat furnace and rapidly heated to just below the melting point, then promptly removed from the furnace and blown cold in a heavy blast of air.

Each test piece shall then have ground off one end by wet emery grinder an amount at least equal to one-half the thickness of the test piece, leaving the end after grinding a V-shape. This V-end shall then test "file hard." Each bar failing in this test shall be rejected and another bar furnished in its stead by the contractors, and failure of 10 per cent of the bars of any lot to meet this test shall reject that lot.

Chemical analyses shall be taken and the steel of each lot shall show the following maximum and minimum limits for the elements named:

	Not less than. Per cent.	Not more than. Per cent.
Tungsten	18.50	19.50
Chromium	5.25	6.00
Vanadium	0.10	0.35
Carbon	0.55	0.75
Manganese	....	0.15
Silicon	....	0.110
Phosphorus	....	0.020
Sulphur	....	0.020

There shall be no other impurities or ingredients, except iron, particularly no molybdenum.

From each lot of tool steel one or more tools shall be forged and treated with the standard high heat treatment and ground to a uniform standard shape of cutting edge for lathe tools; these tools shall be given a standard 20-min. test on a steel forging of the following chemical and physical characteristics—viz., to be open hearth, either nickel or carbon steel, annealed:

Minimum tensile strength, 80,000 lbs.

Minimum elastic limit, 50,000 lbs.

Minimum elongation in 2-in. (cold bend about an inner diameter of 1-in. through 180 degrees), 25 per cent.

Maximum phosphorus, 0.06 per cent.

Maximum sulphur, 0.04 per cent.

The lathe tool, known as the standard 7/8-in. tool, shall be able to take a cut of 3-16-in. depth, with 1-16-in. feed, at surface speed of 60 ft. per minute.

Following is the preliminary report, under date of Jan. 29, 1909, of the board on tool steel, supplementary to that dated July 27, the board being composed of the same officers with the exception of Captain Parks, whose place was taken by Commander F. C. Bowers, U. S. N., Bureau of Steam Engineering:

REPORT ON CARBON TOOL STEEL.

The board has been unable to obtain sufficient data and information on which to base detailed specifications for the several grades of carbon tool steel that will be necessary for different kinds of work. It has been collecting information and data, and, pending completion, this preliminary report is submitted for the purpose:

1. Of making recommendations as to the number of grades of carbon tool steel that shall be purchased for general use;

2. To recommend the standardization of methods of treatment for carbon tool steel as was recommended for the high speed steel;

3. To indicate the lines along which the board is working so that the heads of various departments in navy yards may be informed, and in order that the board may receive information developed by them in the course of such work as they may do on those lines.

Taking in order the four acts named in the department's memorandum precept, the board reports upon:

1. The Qualities Desirable in Tool Steel and the Necessary Chemical Composition to Obtain Those Qualities.

As stated in previous reports, the essential quality of all tool steel is uniformity in each and every grade. The chemical composition must be so specified for each grade as to insure such uniformity; it should be such as to render a tool as little liable to be ruined in forging, treating or grinding, and to permit of as wide range of temperature for forging as possible. It should be such as to insure that the best possible results will be obtained from the standard method of forging and treating, which should be adopted and used at all navy yards.

The board considers this point of the utmost importance, is if steels requiring different treatment are purchased there is no way by which the tool dresser can ascertain the treatment to give to a particular tool, unless he can identify the brand of steel of which it is made and the instructions for its treatment are at hand. This ordinarily will not be the case and the steel will be treated in accordance with usual custom, with results that will be generally far from satisfactory. In this connection the board deems it not improper to quote the opinion of F. W. Taylor, the leading authority of tool steel in this country, expressed in his book, "The Art of Cutting Metals":

The two operations of hardening and tempering implements made from tool steel are by no means simple. They have been the subject of a vast amount of experimenting and investigation for many years, and in themselves constitute whole trades.

The chief difficulties in hardening come from three causes:

(a) Each ordinary tool steel, depending upon its chemical composition, has a particular temperature at which a radical change takes place in the condition of the carbon which is contained in it. This temperature, known as the "refining point," "critical point," or "point of recalescense" of the steel, will be briefly referred to later in the paper. In order to obtain the

best results in hardening, the steel should be uniformly heated to slightly above this critical point. If heated below the critical point it fails to harden when plunged into water. On the other hand, the higher the temperature to which it is heated above the critical point the coarser will be the grain, with increased weakness and brittleness after being plunged into water. This overheating of carbon steel tools to temperatures too high above the critical point has been in the past, perhaps, the most frequent cause of their failure. Hence the difficulty in judging the critical point for heating tools presents one of the most serious problems in hardening.

(b) The second difficulty lies in not heating the tools uniformly. A lack of uniformity in heating will produce irregularity in the degree to which the tool is hardened, some portions being much harder than others after quenching, and this sets up severe internal strains in the tool, frequently developing into water cracks.

(c) The third difficulty lies in properly cooling the tools in the water or quenching medium. Uneven or irregular cooling also produces severe internal strains, often resulting in water cracks.

The board considers the question of treating tool steel of the utmost importance, and the necessity is urgent for ascertaining the adopting for immediate use an exact method of treatment that will give the best and uniform results for each grade of tool steel used. Furthermore, the board believes that the great object to be attained in the successful treatment of tool steel is to get away from the old method of telling the degree of heat the tool has reached by the eye; it should be brought to as nearly a mechanical process as possible, which can be done by adopting the time element in the treatment. Furnaces should be used that will keep, so far as is practicable, a steady heat at the desired temperature, and be provided with a pyrometer for indicating the temperature attained.

The board has been unable to conduct experiments along this line, in the absence of facilities, but recommends that experiments be conducted at the various navy yards and especially at the experimental tool grinding and tool dressing plant at the Philadelphia yard, to determine the most efficient method of treatment of carbon tool steels of the various grades, as recommended to be adopted further in this report.

2. The Shapes Desirable.
3. The Sizes Desirable.

The board has no further comments to add to those included in its former report, beyond the statement that for the purposes for which carbon tool steels are used the number of sizes and shapes is diversified. Stock sizes and shapes should be limited strictly to those required for current demand, and no purchases should be made of sizes and shapes unless such are known to be regularly used. Where special sizes and shapes are required for a special purpose, purchases should be limited to the amounts so needed and requisitions for tool steel should be scrutinized carefully with this in view.

4. The Different Proprietary Brands and the Reasons Therefor in Each Case.

The board is of the opinion, as expressed in its previous report, that uniformity in quality and characteristics of the various grades of tool steel can be had best by buying all tool steel for the navy subject to specifications, the lowest responsible bidder to be awarded the contract subject to acceptance or rejection of the deliveries as they conform or fail to conform to the requirements of the specifications, and meet or fail to meet the prescribed tests. Furthermore, bidders should be required to agree to replace bars which may be found to be defective in use.

The board is further of the opinion that three grades of carbon tool steel will be sufficient for all general requirements at the navy yards. These grades should be designated A, B and C, respectively, and should be required to be crucible steel, having in general the following characteristics:

Grade A for finishing steel, special machine cutting tools, and other purposes for which a high grade of tool steel is required, but for which high speed tool steel is not suitable. It is the board's opinion, however, that the use of the high speed steel may be extended economically for many of the purposes for which carbon steel now is used, thus reducing the amounts of Grade A steel required. Grade A steel should have a chemical composition approximately as follows:

Carbon, not less than 1.20 per cent.
Silicon, not less than 0.30 per cent.
Manganese, not less than 0.20 per cent.
Phosphorus, not more than 0.02 per cent.
Sulphur, not more than 0.02 per cent.
Tungsten, not to exceed 3 per cent, if found to be desirable.

Grade B steel for taps, dies, milling cutters, drills, forming tools, special chisels, dies, punches, etc. This grade of steel should have a chemical composition approximately as follows:

Carbon, not less than 1.00 per cent.
Silicon, not less than 0.20 per cent.
Manganese, not less than 0.20 per cent.
Phosphorus, not more than 0.025 per cent.
Sulphur, not more than 0.025 per cent.

Grade C for purposes which would not justify the use of the higher grade and more expensive tool steels, also for tools subject to percussion, such as chisels for cold and hot work, blacksmith's tools. Also for rivet punches, dies, shear-blades for structural steel work, hand bars, etc. This grade of tool steel should be comparatively low in carbon. Its composition would be approximately low in carbon. Its composition would be approximately as follows:

Carbon, not more than 0.90 per cent.
Silicon, not less than 0.15 per cent.
Manganese, not less than 0.15 per cent.
Phosphorus, not more than 0.028 per cent.
Sulphur, not more than 0.030 per cent.

Determination of carbon in all cases by the combustion method.

In addition to the chemical requirements mentioned for each of the above grades of steel, certain definite physical tests will be specified. These will have to be based on experience with tool steel purchased in the ordinary manner, but following, so far as possible, the above classification.

The method of treatment to which each grade of steel must respond should be specified, but the details of such treatment can be determined only after experiments conducted in the manner indicated above.

The board has been unable to obtain data along the lines indicated, owing to the somewhat haphazard method now pursued in the purchase and treatment of tool steel, but it believes that, with information that can be obtained when the experimental tool steel plant at the navy yard, Philadelphia, is put into operation, that such methods of treatment may be determined upon that will permit the best results to be obtained from the various grades of tool steel in the same manner as was done in the case of the high speed steel.

Naval Constructor Williams states that several contracts have been awarded for high speed tool steel under the specifications as above adopted and the results have been generally satisfactory. He further says that while they cannot be regarded as being conclusive in establishing the correctness of the particular specifications, they do establish, without question, the desirability of purchasing tool steel on a specification of this character.

ELECTROLYTIC DETERMINATION OF COPPER.*

Edited By F. W. TRAPHAGEN.

Almost without exception, the electrolytic method is the one used for all shipment and settlement assays on copper products.

The following methods are those worked out by the Chemical Staff of the Anaconda Copper Mining Co., and will be found generally available for the materials described.

Allow about .11 ampere for each determination. With the present arrangements in the electrolytic room (103 volt lighting circuit) this gives a tension of from 1.40 to 2.30 volts.

In all cases a drop of the electrolyte is brought in contact with a drop of H_2S water on a spot plate to test if copper has been completely deposited.

The platinum cylinders with deposited copper are washed in water, then alcohol, dried on a steam bath and weighed.

If deposited copper is dark from presence of arsenic, it is dissolved in 8 c.c. HNO_3, diluted with water and electrolyzed again, care being taken to remove solution from the battery soon after the complete deposition of the Cu.

*From the Western Chemist & Metallurgist.

Copper may be separated from Bi, Sb, and As, by precipitation as sulphocyanide, the precipitate washed thoroughly, ignited gently in porcelain crucible, dissolved in 7 c.c. of HNO_3, and Cu determined electrolytically.

In samples containing As, Sb, Te, and Se, such as electrolytic slimes, add 100 mgs. of Fe to the HNO_3 solution of sample from which silver has been removed as chloride. Add ammonia to precipitate Fe and still have solution acid.

Bring to boil, settle, filter off Fe precipitate; re-dissolve and precipitate as before. A third precipitation may be necessary to be certain of having all Cu in the solution.

Combine filtrates and electrolyze. The Fe precipitate holds the AS, Sb, Se, and Te.

Converter Copper.—Dissolve ½ gram in 8 c.c. HNO_3, 8 c.c. water and 1 c.c H_2SO_4 keeping covered during solution. When solution is complete and fumes expelled fill breaker with water and place on battery.

In the Cu determinations on mattes and converter copper the percentage of silver, as determined by fire assay is deducted from percentage of Cu + Ag found by electrolysis. (291.66 oz. = 1.00%). The Ag may be precipitated with just sufficient dilute NaCl, care being taken to avoid an excess. The silver chloride is filtered off and the Cu alone deposited by the current.

Mattes.—Moisten one gram sample with a few drops of water, add 8c.c. HNO_3 and 1 c.c. H_2SO_4. Take to dryness on steam bath. Take up with water and 8 c.c. HNO_3. Filter and place on battery.

Slags.—Decompose two grams in platinum dish with 8 c.c. HNO_3, 8 c.c. HF and 1 to 2 c.c. H_2SO_4. Evaporate to SO_3 fumes. Take up with water and 10 c.c. HNO_3. Place on battery.

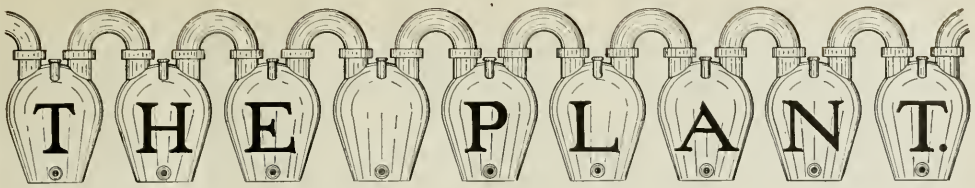
Sulphide Ores.—Weigh one gram of sample into a beaker (3½ in. high and 2¼ in. in diameter). Add 8 c.c. HNO_3 and a little $KClO_3$.

Take to complete dryness on steam bath.

Take up with water and from 6 to 10 c.c. HNO_3. Fill beaker with water, let settle, then place on battery.

Oxidized Ore.—Use 1 gram sample. Take to dryness with 8 c.c. HNO_3. Add 10 c.c. HCl and 2 c.c. H_2SO_4 and take to SO_3 fumes. Take up with 8 c.c. HNO_3 and water, let settle and place on battery.

The Dominion Steel Co. has organized a subsidiary company to erect plants for making wire, wire nails, and other finished wire products. The company has heretofore manufactured only wire rods for wire and nail mills throughout Canada, but the merger of several of these mills has led the steel company to make new plans for protecting its own interests and those of its customers who have not gone into the merger. The company already employs 12,000 workmen.



LOSS IN COAL DUE TO STORAGE.*

By A. Bement.†

In recent years, the threatened interruption of coal production brought about by the cessation of mining, pending wage settlement between operators and miners, formally designated as strikes, has made it necessary, particularly for large users of coal, to carry fuel in storage for use during the time that mines may be inactive. Thus the question of its deterioration under such conditions is one of interest.

During the last few years the author has made investigation concerning the deterioration of certain Illinois coal, for Mr. W. L. Abbott of Chicago. The first work consisted in experiments to ascertain the loss in heating power. While that work was largely of a preliminary nature, the loss in heat value appeared to be much smaller than popularly supposed. As an experiment of this character requires a considerable period of time, due to the fact that it is necessary to test the coal in its original condition and then again after storage, such investigations extend over long periods of time. The experiments in question covered a period of some three years, with fuel which has been exposed in outdoor storage in each case for one year. Upon the completion of the first year's work it was felt that the matter of loss or gain in the weight of fuel, or in other words, its quantity, as well as heating value was an important feature. To this end, during the second year, experiments were made to ascertain change in weight as well as in heating power; while the work gave useful results, as well as developing an accurate method of testing, they were really of preliminary character. At this point, having the benefit of two years' experience, another series of tests was planned and carried to a very successful conclusion, giving results, which the author believes to be especially accurate and which may be accepted with confidence.

The tests consisted of:

(a) Change in heating power.
(b) Change in weight of the coal.
(c) Tendency to disintegrate by slacking.

The greatest difficulty was in accurately determining the change in weight, and as the sample must be exposed to the weather under representative conditions, it was subjected to the possibility of an increase in quantity, due to dust and dirt which might be carried into it by the wind, or, on the other hand, subject to loss by small particles of coal, which might be washed away by water from rainfalls, which would pass through it, or carried away by wind. To guard against these contingencies, coal containing no dust was selected; placed in a box large enough to hold a 400-pound sample, covered with cheese cloth to catch dirt. Drainage from the box was so arranged that the water would flow at a low velocity through a trough, in which dams or riffles were placed to catch any dust that might be carried out with the water. In preparing the sample of coal to be tested a size was selected which in preparation passed over a screen having ¼-in. round perforations and through one with ⅝-in. perforations. This sample was then taken in an air dry state and carefully rescreened over a screen having ⅜-in. perforations. This rescreening eliminated all of the small stuff and left a clean uniform size of coal, which was then sampled for analysis, the remainder being weighed and placed in storage in the box and the sample analyzed. When the coal was taken out of storage its weight was taken, it was then sampled and again analyzed. Heating power determinations were made with a Mahler calorimeter at the same time the analyses were made. In determining change of weight, calculations were based on the same moisture content as that present in the coal in the initial state. This was because coal does increase and decrease in moisture content independent of any change that may affect the ash content or that of the coal proper. Thus the final weight of the dry coal referred to its initial weight gave the change due to weathering.

Illinois coal production is practically all from four seams, but the Illinois coal used in Chicago for steam production is nearly all from two of these seams, which are Nos. 5 and 6. In fact, these two seams produce 75 per cent of the entire output of the state. Seam No. 6 is by far the larger producer of the two. Until recently, however, that portion of seam No. 6 lying east of the city of DuQuoin, in Perry County, which is extensively operated in Williamson, Franklin and Perry counties, has been known as No. 7. One of the things that gave reason for belief that it was a different seam from No. 6 is that the quality of its coal is better than that in the remainder of the seam to the west and north. Thus the two general fields in this seam have a different character.

Seam No. 5 in the vicinity of Springfield, also produces a considerable amount of coal finding market in Chicago, while the principal fuel supply is from seam No. 6, it was felt desirable also to test the behavior of

*Paper read at the semi-annual meeting of the American Institute of Chemical Engineers, June 22-24, 1910.
†Consulting Engineer, Fisher Building, Chicago, Ill.

that seam as to change in heating power and its tendency to disintegrate by slacking down to smaller size. The reason why no test for change in weight was made, was that at the time it was felt that the data from Seam No. 6 would be sufficient. Therefore, a sample of mine run coal corresponding to the others in amount was put in storage for that purpose, which was analyzed and heating power determinations made upon it, the same as with the two samples from seam No. 6.

The average composition of seams in the three fields tested, is given in Tables 1 and 2, which serve to show the character of the coal.

TABLE NO. 1.—PROXIMATE COMPOSITION OF COAL SEAMS.

	No. 5 Springfield.	No. 6 Central.	No. 6 Southern.
Moist Coal:			
Moisture	12.66	14.38	9.65
Ash	10.75	10.01	10.99
Volatile matter	37.23	36.23	31.55
Fixed carbon	39.36	39.38	47.81
Heating power in B. t. u.	10,990	10,774	11,178
Dry Coal:			
Ash	12.31	11.69	12.16
Volatile matter	42.63	42.32	34.92
Fixed carbon	45.06	45.99	52.92
Heating power in B. t. u.	12,583	12,584	12,803
Pure Coal:			
Volatile matter	42.63	42.32	34.92
Fixed carbon	51.39	52.08	60.25
Heating power in B. t. u.	14,350	14,250	14,575

TABLE NO. 2.—ULTIMATE COMPOSITION OF COAL SEAMS, PURE COAL BASIS.

	No. 5 Springfield.	No. 6 Central.	No. 6 Southern.
Carbon	77.23	75.74	81.63
Hydrogen, available	4.02	3.63	4.02
Sulphur	4.45	5.24	2.14
Nitrogen	1.60	1.51	1.73
Water of Combination	12.70	13.88	10.48
Total	100.00	100.00	100.00

Table 3 gives the results of the tests showing change of weight and heating power, with the exception that as no determination was made of the change of weight with the sample from seam No. 5, the figure used to represent this loss was derived upon an assumed basis to be described later.

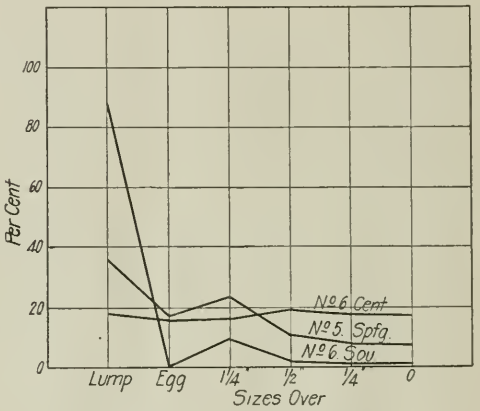
The question of change in coal stored under water was also a matter which presented itself and tests conforming to those above described were made upon samples stored under water for one year in glass jars, which sat upon a shelf in the laboratory. The result of these tests is presented in Table 4.

In Illinois, as well as the remainder of the Eastern Region of the Interior Coal Province, the product is lump, mine run, egg, nut and screenings. When storage was first attempted, in many cases screenings were stored. It was found, however, impracticable to handle such fuel on account of its catching fire, some-

TABLE NO. 3.—CHANGE DUE TO EXPOSURE IN AIR.

	Change in per cent.		
Coal Seams.	Heating power.	Weight.	Total.
5 Springfield	—0.93	—1.15	—2.08
6 Central	—1.85	—2.29	—4.14
6 Southern	—0.38	+0.11	—0.27

times very soon after being put in the pile, and it was also found that mine run would store with very much less danger of fire. With this larger coal, however, it was also discovered that there was a disposition for it to disintegrate and slack down into smaller size. Thus the best practice has been to place egg coal in stor-



Disposition of Lump Coal to Slack
Exposure of one year. Original samples 100% lump, which outdoor storage broke down to sizes as shown.

age, as it appears to show the least tendency to deteriorate by slacking and is free from spontaneous combustion if not disturbed until used.

The disposition of coal from the three fields in question to disintegrate by slacking down into smaller size,

TABLE NO. 4.—CHANGE OCCURRING UNDER WATER.

	Change in per cent.		
Coal Seams.	Heating power.	Weight.	Total.
6 Central	—0.44	—0.35	—0.79
6 Southern	+0.02	—0.81	—0.73

was considered a matter of sufficient importance to justify careful tests to determine this feature. Therefore a considerable number of average lumps of coal from each of the fields were placed in outdoor storage for one year, the weight being taken at the start. These lumps were so placed that the portion scaling off re-

mained associated with the original lump. At the end of the year that portion of the original lumps remaining intact, were weighed and their total weight referred to the original weight, gave the percentage of the original lump still remaining intact. The remaining portion was separated into sizes each of which was also weighed, thus showing to what extent the sample remained as lump and to what sized pieces the disintegrated portion was disposed to take. The result of these tests is illustrated in the accompanying diagram which shows that coal from seam No. 6 Southern retained its integrity as lump to the extent of 87.84 per cent, while No. 5 retained it to the extent of 35.49 per cent and No. 6 Central only to an extent of 18.36 per cent.

After the work was completed, it appeared desirable to have, as above mentioned, some figure representing a value for change in weight for seam No. 5. Therefore, the figure used in the table was determined by assuming that the tendency for loss in the weight would be in the same ratio as the tendency to deteriorate by slacking, thus the figure representing a weight loss of 1.15 per cent was arrived at.

BUYING CARBON TOOL STEEL ON SPECIFICATION.*

By J. M. DARKE.

Three years ago the writer conceived the idea of buying carbon tool steel on a specification basis, in the same manner as many other materials used by large manufacturing concerns are purchased. When the subject was broached to those most interested it was received with little enthusiasm. The manufacturers of carbon tool steel were not in favor of the idea, as it removed at once the value of their brand of trade names, upon which they had spent years of advertising, and which represented the real difference between their steel and the steel made by competitors. The master mechanics and the shop foremen were somewhat doubtful as to its success, as the idea was so radically different from the system under which they had been working for years. Many of them were men of long experience who had used certain brands of steel for years, and it semed impossible to them that there were dozens of other brands equally good. It is also natural to feel that in adopting a scheme which removes the responsibility of making a choice in selecting steel, something quite personal has been lost.

Others objected to the idea on the ground that "chemical analysis was not the whole thing."

This is true in a narrow sense. This same argument was advanced when the chemist was introduced into iron and steel foundries and various other industries. Through the lack of exercising ordinary common sense, the chemist came very near being an absolute failure in the iron foundry business. This would be the outcome if chemistry were applied in the same manner to a tool steel specification. Chemistry properly applied is a great aid in determining the quality of tool steel, but it will not tell whether the steel was made in an open hearth furnace or a crucible. The microscope will answer questions that chemistry cannot. The specification was, therefore, drafted to include both chemical and microscopical analysis.

A large number of American manufacturers of carbon tool steel were asked to submit samples representing their various brands. These samples were carefully analyzed, photomicrographs were made, and results compared. It was found that the steels grouped themselves into three grades, one about a 7-cent base, the second about a 14-cent base, and the third about a 22-cent base; the latter usually being a "double special" steel, and generally containing some alloy.

The various tool steel mills were visited by a committee, including the writer, and as representatives of a large consumer of tool steel, we were afforded exceptional facilities for investigating the plants. We found that all the mills visited were well equipped, both in men and apparatus, for making good tool steel, and that they were honestly trying to maintain a high standard. In short, there was no reason why any one of the mills visited could not produce as good steel as its neighbor.

With the above facts in mind, the following specification was drawn up and presented to the trade:

SPECIFICATION FOR CARBON TOOL STEEL.

1. Tool steel to fill this specification will be required in five classes and three grades, as follows:

	Carbon, per cent.
Class No. 1	0.75 to 0.85
Class No. 2	0.85 to 0.95
Class No. 3	0.95 to 1.10
Class No. 4	1.10 to 1.25
Class No. 5	1.25 to 1.40

	Grade A, per cent.	Grade B, per cent.	Grade C, per cent.
Manganese	0.25 to 0.45	0.25 to 0.35	0.25 to 0.35
Silicon, not over	0.20	0.15	0.12
Phosphorus, not over	0.03	0.020	0.010
Sulphur, not over	0.04	0.020	0.010

2. The steel to be crucible steel properly melted in crucibles, not so-called "crucible analysis," with the exception of Grade A, which may be acid open hearth steel.

3. The steel shall have been sufficiently forged to refine the grain, and forging stopped at such a temperature that the maximum refinement of grain will be obtained.

4. Steel containing the exact minimum amount of carbon in any class will be considered as belonging to the class below.

5. The steel shall be free from flaws and other imperfections.

The 22-cent grade of steel was discarded; being an

*From the General Electric Review.

alloy steel, it could not be included in a carbon steel specification. A very low grade was added to cover such steel as would be suitable in open hearth.

The various manufacturers were asked to quote prices on the different grades, which, with one or two exceptions, was done.

As an aid to the application of the specification Table 1, giving the class and grade of tool steel for various purposes, was compiled. Such parts are omitted as are not of general interest.

This table was compiled by a tool steel committee composed of representative men from the departments using tool steel. Each article was fully and carefully considered, and many of the selections (not appearing in table as printed) were the result of extended practical trials made in the shop under the supervision of a member of the committee. Valuable suggestions received from tool steel manufacturers were also incorporated. The table is subject to revision as experience renders necessary. New copies are issued to department heads and shop foremen whenever changes are made.

TABLE 1—CLASS AND GRADE OF TOOL STEEL FOR VARIOUS PURPOSES.

	Grade A.	
Class 1.	Drop dies.	
0.75 to 0.85 C.	Dies for hammers in blacksmith shop.	
Class 2.	Cams.	
0.85 to 0.95 C.	Sheet steel for lathe springs. Centers.	
Class 3.		Miscellaneous steel for blacksmith shop.
0.95 to 1.10 C.		
Class 4.	Spring (coil) springs (Spec.).	Miscellaneous steel for die room.
1.10 to 1.25 C.		Large reamers.
		Sheet steel for slotting saws.
		Large dies.
		Large taps.
		Letters.
		Milling cutters over 2 in. in diameter.
		Drill rod.
Class 5.		Milling cutters 2 in. under.
1.25 to 1.40 C.		Small dies.
		Chaser.
		Gravers.
		Dies for heading machines.

HOW STEEL IS ISSUED TO THE DEPARTMENTS.

When tool steel is required by the various departments requests for it are placed by the heads of departments with the stock and order department. These requests or orders are then referred to the laboratory department to insure that the proper class and grade of steel is specified for the work in hand. The orders are entered in a record book, O. K.'d and returned to the stock and order department for placing with the steel manufacturer. A copy of the requisition as placed with the steel manufacturer is also kept on file in the laboratory.

The tool steel is received by the receiving department, who notify the chemical laboratory and the shop foreman for whom the steel is ordered. The date of receipt is entered in the record book in the laboratory.

The shop foreman, upon receiving the steel, cuts off small samples, or in case of large bars, takes drillings and sends them to the laboratory properly marked. Analysis for carbon, phosphorus and sulphur is then made, and if according to specifications, the shop foreman receives a copy of the analysis, which constitutes a release and the steel may be used. If not in accordance with specification the inspection department is notified and the steel rejected. Making the necessary records and analyses occupies very little time and costs on an average 50 cents per sample.

A brief statement of methods employed in the chemical analyses may be of interest. The carbon is determined by direct combustion of the drillings in a platinum tube, and requires 15 minutes' time. The phosphorus is determined by the Jones reductor method, and requires about 30 minutes. The sulphur is determined by the iodine titration method, and requires about 30 minutes. One operator can make several phosphorus or sulphur determinations in very little more time than it required for one determination. Silicon tests are made occasionally and require 3 hours' time, only a small portion of the work demanding the chemist's attention.

Microscopical examinations were made frequently when the specifications were first adopted, but it was found that the steel ran so uniformly good in this respect that now the examinations are made only occasionally. This would be the first test made, however, in case of trouble.

ADVANTAGES OF THE CLASSIFICATION.

The steel is received without labels, but each bar is stamped with its class and grade, and the symbol designating the maker. For instance, steel of Class 5, Grade C, ordered from the Crucible Steel Co. of America, would bear the stamp when received, 5-C-A; of Grade B, 5-B-A, etc.

Before adopting this specification we had 109 brands of steel listed, ranging in price from 7 to 35 cents per pound, any one or all of which might be in the factories at any time.

The individual shop foreman decided whether he would use one or the other. It was impossible to keep all these brands separate, and the brand was no guarantee that the carbon content would be right for a given purpose. We were apt to get a high carbon steel for a hammer and a low carbon steel for a mill-

ing cutter, as all tempers were carried in the same brand.

The specification has greatly simplified stock keeping, as now five classes and two grades cover 98 per cent of our requirements. We have uniformity of product and a considerable assurance that the steel contains the right amount of carbon to render maximum service when used for the purpose for which it is intended. This is due to the fact that the selection of steel is governed by the table before referred to, entitled "Table Giving Class and Grade of Tool Steel for Various Purposes."

As there are only three grades of steel called for in the specification, we have only three base prices. This gives a uniformity of prices and a definite basis for figuring costs.

The failures in hardening have been reduced to a minimum, because the hardeners know from the class of the steel the amount of carbon contained, and, therefore, the proper annealing and hardening heats. With furnaces properly equipped with pyrometers, and the carbon content of the steel known, most of the elements of failure in hardening have been removed.

While the primary object of the specification was to secure uniformity, it has considerably reduced the total cost of tool steel. This reduction of cost has been obtained, not only by competitive bidding on the specification, but by selecting high priced steel only where it was needed. The total saving cannot be readily determined, since so many factors enter into the calculation, such as increased life of tools and less breakage in hardening of parts involving large amounts of labor.

According to a report issued by the U. S. Consul General at Hamburg the present prices of nitrate is $1.59 per quintal (101.61 lbs.) for the 95 per cent product and $1.65 for the 96 per cent product, with 1 per cent salt, for immediate delivery free alongside ship. Of the 154 oficinas or nitrate manufactories in Chile, 55 are not being worked, 36 being closed before July 1, 1909, some for some time previously on account of having worked out their nitrate ground, or the cost of production from various causes having been too high. The oficinas in which the cost of production is low are reported as being worked to their limit, taking advantage of the cessation of restrictions regarding production, at the discontinuance of the nitrate combination.

According to a U. S. Consular report, the power that can be developed from the waterfalls of Sweden is about 7,500,000 kw. Three-fourths of the larger falls are in Norrland. The state at present owns 277 falls. The largest fall now managed by the state is Trollhattan, the water of which is expected to produce 60,000 kw., but at present is producing only one-half of that amount. At the Porjis Falls, in northern Sweden, 37,500 kw. is expected to be realized

METHOD FOR DETERMINING POTASSIUM IN SODIUM CYANIDE.*

By J. E. CLENNEL.

In the examination of commercial cyanides, I have found the following method for determining small amounts of potassium in the presence of sodium as given by Finkener and modified by Dittmar and MacArthur, to give accurate results.

Evaporate about a gram of the sample with sulphuric acid in sufficient quantity to convert all the salts present into sulphates. Redissolve the residue in water and add about 1.25 times the quantity of platinic-chloride solution (i. e., chloroplatinic acid H_2PtCl_6) required to convert the whole of the potassium supposed to be present into K_2PtCl_6; in other words, add 3⅛ parts of platinum for every part of potassium. The amount of platinum needed in this method is much less than in the ordinary (Tatlock's) method, in which not only the potassium, but also the whole of the sodium must be converted into a platinum salt. Warm till the chloro-platinate precipitate just dissolves, adding a little water if necessary. Then evaporate on a water bath to a very small volume and stir to prevent the formation of large crystals.

After cooling, add 10 c.c. absolute alcohol, then after some time, 5 c.c. of ether. Mix well and allow the precipitate (K_2PtCl_6 and Na_2SO_4) to settle thoroughly, say for two hours, under a cover, to avoid undue evaporation. Then decant the liquid through a filter and work with a mixture of one volume of ether and two volumes of alcohol until free from soluble platinum salt.

PRECAUTIONS IN USING AMMONIUM CHLORIDE.

Digest the residue in a cold saturated solution of ammonium chloride, which readily dissolves Na_2SO_4, and $MgSO_4$ if present, leaving K_2PtCl_6 undissolved. Collect on a small filter, work as quickly as possible with NH_4Cl solution until free from sulphates, then run alcohol through to remove part of the ammonium chloride.

Dissolve the remaining precipitate in hot water, adding 1 c.c. water for every 5 mg. of platinum present. Transfer to a conical flask of about twice the volume of the liquid. Immerse this flask in a water bath at 80 to 90 deg. C., and lead through it a current of hydrogen gas, purified by passing through a wash bottle containing silver nitrate, until the liquid in the flask is completely discolored. The chloro-platinate is reduced as follows: $K_2PtCl_6+2H_2=4HCl+2KCl+Pt$.

As a precaution, CO_2 may be used to displace the hydrogen at the finish. Collect the reduced platinum on a filter, wash the water until free from KCl, ignite and weigh. From the formula, K_2PtCl_6, it is obvious that one atom of Pt corresponds to two atoms of K, hence $Pt \times 0.402 = K$.

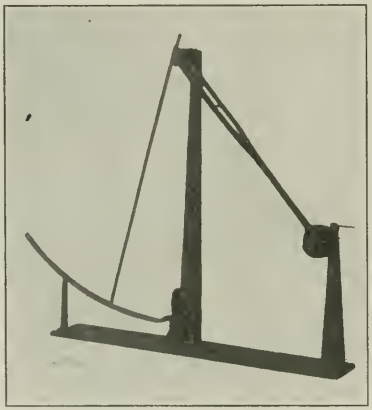
*Engineering & Mining Journal.

NO LOSS OF PLATINUM.

As the platinum is recovered in a pure finely divided metallic form, it is easily reconverted into Chloroplatinic acid by digesting with chlorine and HCl in a stoppered bottle. The solution so obtained is then evaporated on a water bath and the residue redissolved to form a solution of known platinum contents. The filtrate containing Na_2PtCl_6 may also be reduced with hydrogen and treated in the same way, so that, with care, there need be no loss of platinum at any stage of the operation.

A NEW MACHINE FOR TESTING THE ADHESIVE QUALITY OF PITCH.

The value of pitch, as a binder in road construction, is due largely to its adhesive quality. A new method of testing for this quality has been devised by W. H. Fulweiler, of the United Gas Improvement Company, and at his request Mr. Thorsten Y. Olsen designed a new type of impact tension testing machine which will subject all samples of pitch to the same conditions and



Device for Testing Adhesive Quality of Pitch.

provide a test which can be duplicated at any time on any machine built on this principle. At the recent convention of the American Society for Testing Materials, Mr. Olsen described the machine as follows:

The method of testing the pitch, consists of forcing apart two specially designed dies held together by the pitch and determining the amount of energy thus required:

To make this method a success two important factors must be considered:

1st. The size and form of the dies.

2nd. The method of applying and recording energy.

The first factor was carefully determined by Mr. Fulweiler, after numerous experiments and the Standard die is 1.1 in diameter with three concentric grooves turned in the one half into which the other half fits in such a manner that when pressed together, a thin filament of pitch will be left on all sides of the concentric grooves. The grooves are also so prepared that the pitch is forced out from the center, thus filling all the grooves uniformly.

The present form of die was shaped to cover the points mentioned above and also by experiment until it reached such a form that any further change altering the thickness of the pitch filament would decrease the amount of energy required to force the dies apart.

As pitch has a certain viscosity, varying considerably with the various grades and with the temperature, etc., it is essential that it be tested always under the same conditions and also owing to this viscosity, it is essential that time as a factor be eliminated in the method of testing.

To force the dies apart, it is therefore necessary to apply impact tension.

The machine designed for this purpose is shown by the illustration. It consists of a weighted pendulum which is dropped a certain height striking a crank lever which in turn forces the dies apart. The crank lever was used as the only medium by which the force of impact could be transmitted to the dies, and at the same time allow the pendulum to continue its course and thus provide a means whereby the energy used in parting the dies could be measured.

The capacity of the machine as graduated on scale eliminates the energy utilized in operating the crank lever by itself, as well as that required to move the set pointer, so that the energy used in parting the dies is read directly off the scale.

The pendulum is held in place and released by a latch as shown in the illustration.

The dies are so arranged that the lower half may by a quarter turn be gripped firmly in the frame of the machine and the upper half is placed in a yoke swung from the crank lever at the top and guided by the frame at the lower end so as to insure a direct straight pull on the pitch.

Thus far, but few tests have been made on this machine as it has only been completed recently. It being a new type of machine, it has taken more time than was expected to perfect it, but as the principle involved is correct, there is little doubt but that this machine will form an excellent one for this purpose.

This type of machine can be arranged so it can make impact tension tests of Standard cement briquettes which may give some interesting data on cement. A machine of larger capacity built on this principle and with the proper gripping device would form an ideal machine for impact tension tests of metals, or of testing small nickel bars over a die in determining the fragility of steel.

All zinc smelters in South Wales, according to the Alkali Inspector's Report for 1909, are experimenting with devices for preventing the formation and escape of zinc fume, and four separate patents have been granted or applied for.

THE DETERMINATION OF SOLUBLE BITUMEN.*

One of the fundamental tests in the examination of bituminous materials is undoubtedly the determination of soluble bitumen, or total bitumen as it is sometimes called, and yet in common with most other tests of such materials, important variations exist in the methods adopted by different analysts. Owing to the variety of materials which are classed as bitumen and to a diversity of opinion as to the definition of the term, this subject is a difficult one to handle in a satisfactory manner, and many analysts have adopted the method of reporting their results, merely as the solubility of the material examined, in a given solvent. This is perhaps the wisest procedure at present, and will be adhered to in the following paper. With the hope of placing this matter upon a more rational basis, it is the authors' present purpose to open a general discussion of the subject by the presentation and brief consideration of data which they have so far secured.

The soluble bitumen determination is employed mainly for the purpose of ascertaining what percentage of material is held in suspension as inert matter in so far as binding value is concerned. Such products are usually divided into two classes, organic and inorganic, and so reported, the separation being accomplished by igniting the residue obtained, until all organic matter has been burned off. The organic matter is often called free carbon, especially in the case of tars, although there are many reasons for thinking that free carbon constitutes only a portion of this substance.

Without entering into a discussion as to what materials should and should not be classed as bitumens, it may be said that in this paper the term is made to include all organic substances commonly known as tars; mineral oils; the commercial residues obtained from each, known as pitches and artificial asphalts; native asphalts; and other solid native organic products composed mainly of hydrocarbons soluble in carbon bisulphide. In view of the variety of substances which are included under this term, and to the fact that mixtures of any two or more may be encountered as commercial products, it is most essential that a method of determining soluble bitumen be selected which is applicable to all or to the greatest number of materials. Accuracy, ease of manipulation, time consumed, and cost are also important factors to be considered, and have been constantly borne in mind by the authors in the work here described.

*A paper by Prevost Hubbard and C. S. Reeve, presented at the 13th annual meeting of the American Society for Testing Materials, Atlantic City, N. J., June 28-July 2, 1910.

In selecting a solvent for our investigations, we noted that carbon bisulphide, chloroform, benzol, toluol, and turpentine, have been used for the determination of total bitumen, and had time permitted it would have no doubt proven interesting to have shown correlated results with the use of each of these materials. As such volume of work would have precluded the possibility of our being able to present these data for discussion at this time, we aimed to select two solvents that would prove scientifically, as well as commercially applicable, and therefore adopted carbon disulphide (C. P. Baker and Adamson) and commercial 90 per cent benzol B. P. 80.5°. We appreciated the fact that chloroform is preferred by some chemists for the reason that in certain cases it exhibits a slightly greater solvent action than carbon bisulphide, but the results as a rule are so slightly different that we doubt its coming into general use on account of its much higher cost. The same objection holds for the use of C. P. Benzol, which would no doubt have given more satisfactory results than were obtained through our use of the commercial material. Turpentine was not considered on account of the difficulty of obtaining a pure product of definite composition.

Having decided upon our solvents, it was our object to apply them in such manner as would be typical of the various methods now in general use among chemists engaged in bitumen work, comparing the results obtained, and possibly recommending or evolving a method that would give a maximum degree of accuracy consistent with a proper economy of time. Consideration was given to the fact that there is a division of opinion among various operators as to the merits of hot or cold solvents, while with some the different forms of extractors appear to be preferred. For the purpose of meeting these conditions, the following general methods of procedure were adopted, using from 1.75 to 2 grams of material to be analyzed in each case.

EXTRACTOR METHOD.

For the purpose of our investigation, the Wiley extractor was selected as embodying the general principles of most of the other types. This form of apparatus may be briefly described as consisting of a glass tube 9 ins. long by 2 ins. in diameter, shaped like a large test tube, and having a metal condenser which is attached to the cover and extends downward through the upper half of the tube. The sample, which has been weighed in the cone of a tarred filter paper, is suspended in a bottomless porcelain receptacle from the apex of the condenser, and the solvent is heated in the bottom of the tube.

A few preliminary tests were made on filter papers of different make and size, single and double, after which the following method was adopted and used throughout the series reported below. Two 15 cm. C. S. and S. No. 575 hardened filters were folded lightly in the usual way after which, taking their center point as the apex, they were rolled into narrow cones, having a diameter of about one inch at the base. They were then counterpoised and 1.75 to 2 grams of material was weighed in one of them. The paper containing the sample was placed inside of the counterpoise filter, the two were suspended in the receptacle of the extractor, and using about 35 cc. of solvent, the extraction was allowed to proceed until the washings came through practically clear. The papers were then removed from the apparatus, dried in a hot-air oven at 100° C., cooled, and weighed.

TABLE I.—RESULTS OBTAINED BY THE EXTRACTOR METHOD.

Material.	Solvent.	Sol. Bitumen.	Organic matter insoluble.	Inorganic matter insoluble.	Ash in filtrate.	Total.	Residue from filtrate on Gooch.
Residual coal tar	Carbon bisulphide	81.01	18.90	.09	...	100.00	....
		81.18	18.82	.10	...	100.00	1.98
Residual coal tar	90% benzol	61.08	38.76	.16	...	100.00	.98
		60.48	30.46	.06	...	100.00	....
Residual water gas tar	Carbon bisulphide	99.80	.08	.12	...	100.00	....
		99.94	.03	.09	...	100.00	.14
Residual water gas tar	90% benzol	99.54	.38	.08	...	100.00	....
		99.11	.77	.12	...	100.00	2.79
Residual petroleum	Carbon bisulphide	99.91	.01	.08	...	100.00	....
		100.17	—.30	.13	...	100.00	....
Residual petroleum	90% benzol	100.35	—.35	...	...	100.00	....
		100.10	—.20	.10	...	100.00	....
Blown petroleum residue	Carbon bisulphide	99.98	—.10	.12	...	100.00	....
		100.13	—.24	.11	...	100.00	....
Blown petroleum residue	90% benzol	100.40	—.40	...	...	100.00	....
		99.97	—.11	.14	...	100.00	....
Bermudez asphaltic cement	Carbon bisulphide	96.80	1.44	1.59	.17	100.00	....
		96.58	1.56	1.72	.14	100.00	....
Bermudez asphaltic cement	90% benzol	96.74	1.45	1.64	.17	100.00	....
		96.74	1.41	1.67	.18	100.00	....
Bermudez asphalt	Carbon bisulphide	95.61	2.29	1.92	.18	100.00	....
		95.73	2.12	2.01	.14	100.00	....
Bermudez asphalt	90% benzol	95.44	2.29	2.09	.18	100.00	....
		95.75	2.12	1.99	.14	100.00	....

For the determination of inorganic matter insoluble it was necessary to accept the stated weight of ash for filter paper, which was deducted from the weight of residue obtained upon ignition of the total insoluble material and the paper containing same.

COLD METHOD.

The sample was weighed in a 100 cc. Erlenmeyer flask, which had been previously tarred. It was dissolved by the slow addition of 100 cc. of solvent, with constant twirling until the material was entirely broken up, after which the flask was in a dark closet for 17 hours. At the end of that time the solution was filtered through a felt of long fiber amphibole asbestos, contained in a large platinum Gooch crucible, which had been previously ignited and weighed.

The form of Gooch crucible best adapted for such determinations hold 30 cc., is 4.4 cm. wide at the top, tapering to 3.6 at the bottom, and 2.6 cm. deep. The felt is made by beating up the asbestos in a mortar and suspending the finer particles in water. The suspended asbestos is poured into the crucible, which has in the meantime been placed in the vacuum filtering flask. As soon as the asbestos has somewhat settled vacuum is applied and the felt deposited on the bottom of the crucible, which is then dried, ignited, cooled in a desiccator and weighed. The prepared felt should be dense enough to just barely transmit light when held so that the bottom of the crucible is between the eye and the source of light. If it is denser than this the filter is apt to clog, and if much thinner to let through the finer particles of insoluble material. With a little practice it is possible to prepare a uniform felt wtihout difficulty.

All the insoluble matter was brought on to the felt by scrubbing out the flask, a slight suction was applied when necessary, and the contents of the crucible washed until the washings came through clear, or nearly so. The crucible and contents were dried in a hot-air oven at about 100° C. cooled and weighed, after which any organic matter was burned off and the

inorganic matter or ash determined by again weighing.

The flask was also dried and weighed in a number of cases in order to determine the possible error due to adhering material or variations in the weight of the flask under different atmospheric conditions. In the case of the asphalt and asphalt cement, the usual procedure of burning off the filtrate and recovering any ash therefrom was followed. The time of subsidence —17 hours—was selected as being sufficient and most convenient, for the reason that the samples could be dissolved and set away at 4 p. m. and be ready for filtration the following morning at 9.

HOT METHOD.

The sample was weighed in a 100 cc. Erlenmeyer flask as before, and broken up by the addition of 50 cc. of solvent. The flask was then connected to a short spiral reflux condenser and placed over a steam bath where the solution was maintained at its boiling point for three hours. The flask was then disconnected and the solution filtered, the procedure being exactly the same as in the cold method.

Bearing in mind the variety of materials which may be classed as bitumens, the authors endeavored to select six typical commercial products which represent through their different origins, three distinct classes of bitumens. We therefore made use of (1) a residual coal tar; (2) a residual water gas tar; (3) a residual petroleum; (4) a blown residual petroleum; (5) a Bermudez asphaltic cement; (6) Bermudez asphalt. A general method of analysis that would prove applicable to such a series of materials should be accurate for the determination of soluble bitumen in practically all bituminous substances with the exception of Trinidad asphalt, which owing to the peculiar nature of its fine material, has thus far been thought to require special treatment, and has therefore been purposely omitted from consideration in the present discussion.

The following tables are not only of interest in comparing the different methods, but the duplicate results show their probable limit of accuracy, as in every instance one set of determinations was made by each of the authors.

TABLE II.—RESULTS OBTAINED BY THE FLASK METHOD, COLD, 17 HOURS.

Material.	Solvent.	Sol. Bitumen.	Organic matter insoluble.	Inorganic matter insoluble.	Ash in filtrate.	Total.	Residue in flask.
Residual coal tar	Carbon bisulphide	77.00	22.89	.11	...	100.00	.06
		77.09	22.79	.12	...	100.00	.05
Residual coal tar	90% benzol	76.75	23.14	.11	...	100.00	.03
		74.00	25.93	.07	...	100.00	...
Residual water gas tar	Carbon bisulphide	98.48	1.43	.09	...	100.00	.00
		98.39	1.55	.06	...	100.00	.05
Residual water gas tar	90% benzol	94.85	5.03	.12	...	100.00	.00
		94.45	5.47	.08	...	100.00	...
Residual petroleum	Carbon bisulphide	99.88	.08	.04	...	100.00	.05
		99.86	.11	.03	...	100.00	...
Residual petroleum	90% benzol	99.71	.19	.10	...	100.00	.00
		99.79	.13	.08	...	100.00	.02
Blown petroleum residue	Carbon bisulphide	99.78	.16	.06	...	100.00	.02
		99.75	.16	.09	...	100.00	...
Blown petroleum residue	90% benzol	99.60	.29	.11	...	100.00	.01
		99.70	.18	.12	...	100.00	.00
Bermudez asphaltic cement	Carbon bisulphide	96.72	1.45	1.54	.29	100.00	.05
		96.60	1.52	1.70	.18	100.00	.00
Bermudez asphaltic cement	90% benzol	96.41	1.84	1.67	.08	100.00	.00
		96.71	1.62	1.67	.00	100.00	.03
Bermudez asphalt	Carbon bisulphide	95.66	2.25	1.94	.15	100.00	.06
		95.65	2.32	2.02	.01	100.00	.03
Bermudez asphalt	90% benzol	95.32	2.60	1.95	.13	100.00	.03
		95.40	2.40	2.04	.16	100.00	.07

In Table I it will be noted that under the column headed "Organic Matter Insoluble," a number of negative quantities are found. This is due to the almost invariable passage of some of the insoluble matter through the first paper and its retention by the second. This, together with the fact that it is almost impossible to wash all of the bitumen out of the paper as evidenced by a residual stain, constitute the chief objections to the extractor method. One other which may be mentioned, however, is that while the closest check results for the tars were obtained with the 575 C. S. and S. filter, this paper proved too close-grained for the asphaltic cement and asphalt, and soon filled to overflowing. B. and A. 9 cm. filters were there-

fore used for these two samples. That insoluble organic matter passes through both filters in the case of the tars is shown by the results in the last column which were obtained by immediately refiltering the filtrate from the extractor, through a Gooch crucible fitted with an asbestos pad. In comparing the two solvents it will be noted that for the tars carbon bisulphide is the most powerful, and that with it closer check results were obtained than with benzol. It may be added that in the extractor that fraction of the benzol coming in contact with the bitumen is probably almost chemically pure.

In Table II it will be seen that very uniform results are obtained by the 17-hour cold method where carbon bisulphide is used as a solvent, the maximum variation in check results on soluble bitumen being under 0.2 of 1 per cent. Here again benzol is shown to be a less powerful solvent for the tars, and gives much poorer check results, the maximum variation being over 2 per cent. It was found that such variations occurred only when different lots of solvent were employed and not when two determinations were made from the same lot. Different lots of carbon bisulphide, however gave as close checks as where the same lot was used. The error due to the small amount of residue remaining in the flask is seen to be negligible, not only in this table but in Tables III and IV.

Table III shows that the flask method hot produces just as uniform results as the 17-hour cold method, when carbon bisulphide is used, and here again 90 per cent benzol is shown to be an inferior solvent. As compared with the cold method, the most noticeable difference is the apparent increase in solubility of the various materials. Much of the organic matter insoluble is known to be in a very finely divided state, and as the method allows no opportunity for quiet settlement of this residue, it was feared that a portion of the insoluble matter had passed through the filter. This seemed to be corroborated by the fact that upon standing the filtrates from even the 17-hour cold tests invariably showed a deposit of insoluble matter in the bottom of the flask.

To determine how much this really amounted to, a series of refiltrations with carbon bisulphide was made on the residual coal tar, the residual petroleum and the Bermudez asphaltic cement, with results as shown in Table IV. All digestions were made in the dark. As the deposition continued beyond the period of three or four days, by which time complete sedimentation should have taken place, we were led to suspect that insoluble matter was actually being formed in the filtrate, possibly through a gradual reaction of the solvent with the bitumen.

Another series of refiltrations starting with one-hour cold digestions shown in Table V, added to this suspicion, which was further confirmed by results given in Table VI where coal tar, digested in cold carbon bisulphide for 52 hours, and then boiled for

TABLE III.—RESULTS OBTAINED BY THE FLASK METHOD, HOT, 3 HOURS.

Material.	Solvent.	Sol. Bitumen.	Organic matter insoluble.	Inorganic matter insoluble.	Ash in filtrate.	Total.	Residue in flask.
		78.76	21.15	.09	...	100.00	.05
Residual coal tar	Carbon bisulphide	78.58	21.35	.07	...	100.00	.00
		75.20	24.73	.07	...	100.00	.00
Residual coal tar	90% benzol	75.88	24.05	.07	...	100.00	.06
		99.42	.51	.07	...	100.00	.06
Residual water gas tar	Carbon bisulphide	99.46	.44	.10	...	100.00	.00
		95.74	4.14	.12	...	100.00	.00
Residual water gas tar	90% benzol	95.73	4.15	.12	...	100.00	.03
		99.85	.12	.03	...	100.00	.03
Residual petroleum	Carbon bisulphide	99.83	.08	.09	...	100.00	.04
		99.73	.21	.06	...	100.00	.00
Residual petroleum	90% benzol	99.83	.12	.05	...	100.00	.00
		99.79	.19	.02	...	100.00	.00
Blown petroleum residue	Carbon bisulphide	99.76	.17	.07	...	100.00	.05
		99.55	.28	13	...	100.00	.01
Blown petroleum residue	90% benzol	99.70	.19	.11	...	100.00	.03
		96.61	1.52	1.53	.34	100.00	.01
Bermudez asphaltic cement	Carbon bisulphide	96.69	1.46	1.57	.28	100.00	.01
		96.52	1.58	1.76	.14	100.00	.00
Bermudez asphaltic cement	90% benzol	96.64	1.51	1.61	.24	100.00	.04
		95.63	2.25	1.92	.20	100.00	.00
Bermudez asphalt	Carbon bisulphide	95.55	2.32	1.97	.16	100.00	.03
		95.33	2.44	2.09	.14	100.00	.00
Bermudez asphalt	90% benzol	95.73	2.20	1.92	.15	100.00	.03

one hour shows a higher percentage of organic matter insoluble than either the 1 or 6 hours cold digestion. In this table it is also seen that the percentage of organic matter insoluble increases with the time of digestion, irrespective of settlement or agitation.

TABLE IV.—ORGANIC MATTER INSOLUBLE REFILTRATION TESTS. (CARBONIC BISULPHIDE.)

Material.	Residual coal tar.	Residual petroleum.	Bermudez asphaltic cement.
First filtration 17 hours..	22.78	.13	1.48
Refiltration 1 day later..	.32	.07	.11
Refiltration 2 days later..	.22	.04	.06
Refiltration 3 days later..	.23	.08	.07
Refiltration 4 days later..	.30	.01	.02
Refiltration 5 days later..	.16	.12	.05
Refiltration 14 days later.	.25	.09	.11
Total refiltration 29 days	1.48	.41	.42
Grand total	24.26	.54	1.90

To determine once and for all whether or not any organic matter insoluble had passed through the asbestos felt, a number of hanging drop specimens were prepared from both original solutions and filtrates for microscopic examination. When viewed under high magnification, these specimens proved conclusively the following facts:

(1) That while suspended organic matter could invariably be detected in the original solution, none was present in either the filtrates from the hot method or from the cold, even when the filtration was made immediately after solution.

(2) That filtrates which showed no suspended material immediately after filtration were found to contain suspended matter upon standing for some time.

(3) That solutions refiltered a number of times during 30 days showed no formation of insoluble material upon standing 3 days longer.

These facts taken in connection with the results given in the preceding tables, would seem to establish the following principles:

TABLE V.—ORGANIC MATTER INSOLUBLE, REFILTRATION TESTS. (CARBON BISULPHIDE.)

Material.	Residual coal tar.	Residual petroleum.	Bermudez asphaltic cement.
First filtration 1 hour...	21.74 21.93 .13	.14	1.52
Refiltration 5 hrs. later..	.10 .43	.10	.14
Refiltration 29 hrs. later..	.42	.05	.09

(1) That prolonged digestion is unnecessary in making soluble bitumen determinations, in so far as the passage through the filter of finely divided insoluble organic matter is concerned.

(2) That upon prolonged contact with bitumens carbon bisulphide causes the precipitation of small quantities of insoluble organic matter.

TABLE VI.—EFFECT OF DIGESTION OF RESIDUAL COAL TAR FOR DIFFERENT PERIODS IN CARBON BISULPHIDE.

Filtered after standing ...	6 hrs.	29 hrs.	53 hrs.	52 hrs. cold 1 hr. boiled
Organic matter insoluble ..	22 hrs.	23.15	23.49	22.74

(3) That this insoluble material is precipitated slowly, but that with the concentrations employed precipitation is practically complete within 30 days.

(4) That for equal periods of time the greatest amount of precipitate is formed during the first 24 hours of digestion.

In view of these facts, it seemed of interest to run a series of soluble bitumen determinations with car-

TABLE VII.—FLASK METHOD, COLD, 15 MINUTES.

Material.	Solvent.	Sol. Bitumen.	Organic matter insoluble.	Inorganic matter insoluble.	Ash in filtrate.	Total.	Residue in flask.
Residual coal tar.....	Carbon bisulphide	78.07	21.88	.05	...	100.00	.03
		78.23	21.74	.03	...	100.00	....
Residual water gas tar.....	Carbon bisulphide	99.23	.70	.07	...	100.00	.03
		99.45	.50	.05	...	100.00	....
Residual petroleum	Carbon bisulphide	99.80	.09	.11	...	100.00	.01
		99.78	.14	.08	...	100.00	....
Blown petroleum residue.....	Carbon bisulphide	99.75	.15	.10	...	100.00	.00
		99.71	.24	.05	...	100.00	....
Bermudez asphaltic cement....	Carbon bisulphide	96.66	1.62	1.52	.20	100.00	.00
		96.58	1.53	1.69	.20	100.00	....
Bermudez asphalt	Carbon bisulphide	95.59	2.30	1.91	.20	100.00	.03
		95.40	2.45	1.95	.20	100.00	....

*Averaged from Tables I, II and III.

bon bisulphide according to the cold method, allowing a minimum length of time for digestion and settlement. This was accordingly done, the filtrations being made 15 minutes after the sample was dissolved.

TABLE VIII.—ORGANIC MATTER INSOLUBLE. COMPARISON OF METHODS. (CARBON BISULPHIDE.)

Method.	Extractor.	Flask cold. 17 hrs.	Flask old. 15. min.	Flask hot. 3 hrs.
1890.		22.80	21.88	21.15
Residual coal tar..	18.82	22.70	21.74	21.35
	.08	1.43	.70	.51
Residual water gas tar	—.03	1.55	.50	.44
	.01	.08	.09	.12
Residual petroleum—	.30	.11	.14	.08
	—.10	.16	.15	.19
Blown petroleum residual	—.24	.16	.24	.17
	1.44	1.45	1.62	1.52
Bermudez asphaltic cement	1.56	1.52	1.53	1.46
	2.20	2.25	2.30	2.25
Bermudez asphalt...	2.12	2.32	2.45	2.32

Table VII, which contains the results of these tests, shows this method to give excellent checks, and in Table VIII the four methods are directly compared.

From these results the authors have come to the following conclusions with relation to the selection of a method:

(1) That for the determination of soluble bitumen carbon bisulphide is to be preferred to benzol for a solvent.

(2) That the flask method with Gooch crucible is to be preferred to the extractor method.

(3) That short periods of digestion are to be preferred to long ones.

(4) With regard to the final selection of a method, it is felt that either the cold 15-minute extraction or the hot extraction will give sufficiently close results for commercial purposes, and that there is little choice to be made between the two.

(5) In favor of the latter, it may be urged that for a determination of soluble matter this method is more scientifically correct, as it shows a somewhat smaller amount of organic matter insoluble.

(6) On the other hand, it may be contended that the cold method gives a more correct idea of what it is desired to ascertain, i. e., the percentage of insoluble material actually held in suspension, for it is believed that while the insoluble organic matter approaches free carbon in composition, a portion of it is composed of hydrocarbons rich in carbon, which are very difficultly soluble in the cold carbon bisulphide, but somewhat more readily in the hot.

(7) So far as this investigation has been carried, the 15-minute flask method would seem to be the most rapid practicable method yet found. It is not improbable, however, that the hot flask method could be shortened and that in both, the quantity of solvent could be diminished somewhat.

Everything considered, the cold 15-minute flask method has been adopted by the laboratory of the U. S. Office of Public Roads until data are forthcoming to show that some other method is superior.

THE CANADIAN GOVERNMENT PEAT FUEL PLANT AT ALFRED, ONT.

The Department of Mines of the Canadian Government has been successfully operating a plant for the manufacture of peat into fuel. This plant is located at Alfred, Ont., about 45 miles from Ottawa, and was installed for the purpose of demonstrating the possibilities of peat bogs. It was placed in operation on May 18 and is to be run for three months to demonstrate the latest process of manufacturing air dried peat. The plant consists of a long peat-storage shed, two small frame houses, a blacksmith shop and a large peat machine. The latter apparatus was imported from Sweden, where there are several hundred such equipments in operation.

The peat deposits at Alfred consist of about 300 acres having an average depth of about 10 ft. The method of working these deposits is to cut a long trench, 19 ft. wide, 8 ft. down in the peat, and then place the peat machine in this cut. A carrier conveys the peat as it is dug from the trench to a hopper. On a 600-ft. circular track in the middle of the bogs are 8 peat carriers, each of which holds 0.7 ton of peat. As each car passes the machine, the ground peat is dropped from the hopper into the machine. A 34-HP. engine, which itself burns about 4 tons of peat fuel per day, furnishes motive power for both hopper and cable cars.

The next operation is to convey the peat in the carriers to what is known as a field press. This spreads the peat upon the ground in long parallel rows and it is then shaped into bricks by means of a three-knived instrument, which is operated by boys. After this, the bricks are allowed to dry in the sun and air for three or four weeks, when they are stored in the peat shed ready for transportation.

The capacity of the plant is about 25 tons per day, and 14 men and two boys are employed to operate it. The men receive $1.75 per day and dinner, while the boys receive 8 cts. for every 1,000 bricks turned over. The superintendent of the plant has stated that he can produce peat for from $1.75 to $1.80 per ton. One and four-fifths tons of peat equal one ton of anthracite. The peat fuel will burn in any stove, but for houses, a special stove is necessary on account of the fineness of the ash. Peat takes about twice as much room for its weight as coal, and it is an excellent fuel to use in connection with producer gas.

Part of the peat fuel is sold in the neighborhood for domestic use and part is shipped to Ottawa for use in a peat-using plant for the production of producer gas which has been established there.

METALLURGY.

COPPER-CLAD STEEL: ITS METALLURGY, PROPERTIES AND USES.*

By WIRT TASSIN.

For many years attempts have been made to cover steel with a copper coat which could be made of any desired thickness, and so to unite the two metals that the combined product could be submitted to any of the usual methods for working metals without destroying the integrity of this union.

The methods tried in the past have been more or less successful failures, both from a metallurgical and a commercial standpoint, and it is only recently that a process has been developed by the Duplex metals Co.,

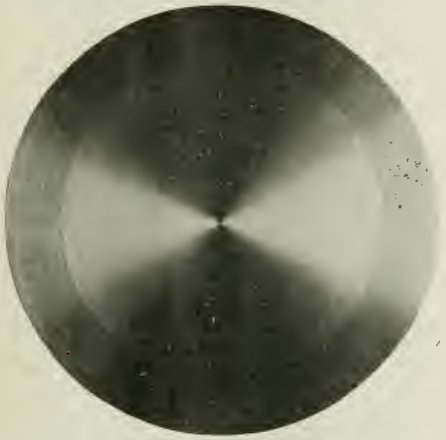


Fig. 1—Cross Section of Copper-Clad Steel Billet.

of Chester, Penn., for the successful welding of copper to steel so that it will withstand the many methods used for working metals and be at the same time, a commercial product.

The weld between the copper and the steel is perfect, within the limits of a metallurgical process. The two metals are united in such a manner that the copper can be separated from the steel only by melting it off. The weld will resist sudden and severe temperature changes, such as heating the metal red hot and quenching it in ice cold water. It will resist stress or shock as shown in Fig. 2, which is a section of a 7-in. round that has had the copper cut through to the steel, the section placed in a vise, and then been repeatedly struck with a hammer.

The clad metals can be rolled, swaged or drawn, hot worked or cold worked, and the proportion of copper and steel existing in the original billet will remain nearly a constant, no matter what the reduction

Fig. 2—Cross Section of Copper-Clad Steel Billet Hammered to Show Weld.

may be, as, for example, from a 6-inch billet to a No. 12 wire.

The process by which copper-clad steel is made may be described as follows: Steel billets of any desired

Fig. 3—Weld Area in $\frac{3}{8}$-in. Copper-Clad Rod, Longitudinal Section. X 150

composition, which for the purposes of this description, will be regarded as being suitable for making tele-

*Paper presented at the 13th annual meeting of the American Society for Testing Materials, Atlantic City, N. J. June 28-July 2, 1910.

phone wire, is rolled to a 5 1-16-in. round. The bar is then cut into 26-in. lengths. The billets so cut then pass to a machine where both ends are drilled and tapped. From here they go into a special pickle. After pickling and washing, the billet is placed in a preheater and is brought up to a given heat. When the desired temperature has been reached, the billet is drawn up into a tube (also previously heated) by means of a rod, and a bushing screwed into the billet. This rod slides up and down in the center hole of a three jawed chuck which holds the tube and centers the billet in it. A steel flange is then screwed on the bottom of the billet, forming with the tube a mold in which the billet is the core.

The mold and billet is now carried to a furnace of special design, which contains a specially prepared copper. The billet with its attached flange is now lowered out of the tube and into this copper, and kept there for a time sufficient to wet the surface of the steel and to form with it an alloy. When the reaction has reached a certain point, the billet is then drawn up into

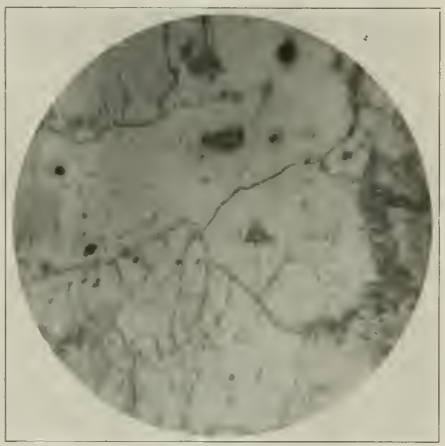


Fig. 4—Cross Section Steel Billet 5 1/16 in., Before Coating with Copper.
X 150

the tube and the whole carried to a second furnace of the pit type, whose pots contain the purest of commercial copper. The tube with its contained billet is lowered into a crucible; the molten copper rushes in through two openings in the top of the tube, unites with the alloyed area and fills the mold. The tube is then withdrawn from the crucible and when the copper has set, the chuck, rod and flange are unscrewed, the copper-clad billet pushed out of the mold, and after the necessary preliminary heating, it is rolled to any desired size and shape.

The rolling is in general similar to that of steel, and it is interesting to note that notwithstanding the differences between the physical properties of copper and steel, the two metals when welded by this process flow practically as one, and the proportional areas of the copper and the steel remain practically a constant from the larger to the smaller passes.

The physical properties of copper-clad steel are noteworthy. Regarding the metal as having 40 per cent of its sectional area copper and 60 per cent made

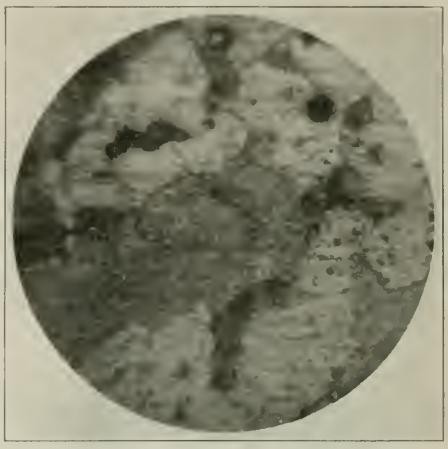


Fig. 5—Longitudinal Section of Steel Billet 5 1/16 in., Before Coating with Copper.
X 150

up of a steel which complies with the following specification: Carbon not to exceed .15; manganese not to exceed .40; sulphur and phosphorus not to exceed .04; its tensile strength after the proper treatment is

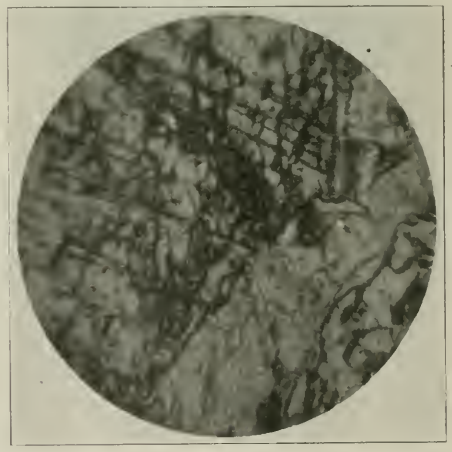


Fig. 6—Cross Section of Steel Billet 5 1/16 in., After Coating with Copper.
X 150

equal to, or closely approximates, and its yield point is greater than that of an all steel rod of an equal section and a similar composition and treatment. An illustration of this is shown in the following table of pulls of ⅜-in. copper-clad and bare steel rods, both

annealed dead soft, and the steel from each coming from the same heat.

	Diam. in Inches.	Yield Point. Pounds Beam.	Yield Point. Pounds Sq. Inches.	Per Cent of Ultimate.	Ultimate. Pounds Beam.	Ultimate. Pounds Sq. Inches.
Bare Steel Annealed	.381	4,800	42,165	77.09	6,200	54,386
	.380	4,650	41,150	77.50	6,000	53,098
	.380	4,580	40,531	78.19	5,870	51,947
	.372	4,400	40,515	71.56	6,150	56,029
	.378	5,080	45,279	82.72	6,020	53,750
Copper-Clad Steel Annealed	.380	5,130	45,399	85.23	6,019	53,265
	.376	5,350	48,198	89.16	6,000	54,054
	.379	4,900	43,362	81.98	5,980	52,035
	.378	5,000	44,643	84.74	5,900	52,678
	.380	4,920	43,539	83.53	5,890	52,124

The values become the more apparent when a comparison is made with the breaking weights of some commercial wires, thus:

Name.	Diam. in Inches.	Breaking Weight.
Galvanized Steel	0.162	1,406
B. B.	0.162	1,250
E. B. B.	0.162	1,140
Copper (H. D.)	0.162	1,237
Copper-Clad	0.162	1,874

These tables tend to show that the tensile strength of copper-clad steel is not the mean of the strengths of the copper and the steel, for the ultimate strength of the copper-clad closely approximates, if it does not surpass that of the all steel rod. This statement applies also to the yield point of copper-clad which will average 84 per cent of its ultimate when dead soft. The elastic limit of copper is about one-third of its ultimate, that of steel is a variable, but, for comparison, take the highest figure given in the table, 78 per cent. Copper-clad steel, four-tenths of whose sectional area is a metal having a relatively low elastic limit, gives a figure greater than that of a similar steel treated under like conditions, and which has a sectional area equal to that of the copper-clad.

These high values are to be accounted for in part perhaps, by the influence of the first dip, or alloy coat of copper, and its effect on the structure of the clad metals, and especially that of the steel. Taking a ⅜-in. rod and developing the structure at the weld area, it will be noticed that there are certain compounds present, Fig. 3, and these compounds, together with the copper, must have a far reaching effect.

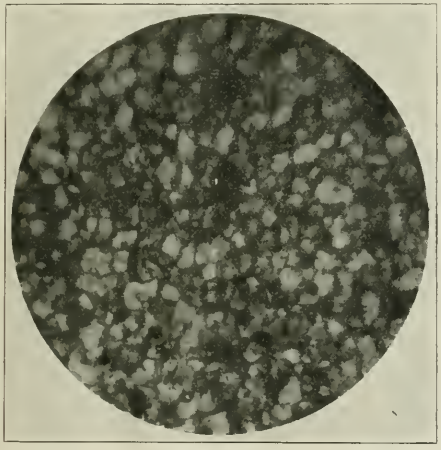


Fig. 7—Cross Section 7⅜ in. Steel Rod. X 150

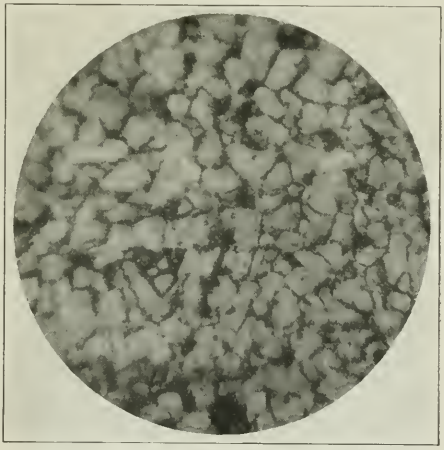


Fig. 8—Longitudinal Section of 2⅜ in. Steel Rod. X 150

In any metal, other things being equal, the finer the grain, the better its physical properties. Starting with this axiom we can find a reason for the high values given by copper-clad in a study of its structure. In Figs. 4 and 5, we have micrographs of the 5 1-16-in. billet before coating with copper. In Fig. 6, we have

the structure of the steel in the copper-clad billet right after coating, and before any heat treatment or work has been applied.

In Figs. 7 and 8 we have the structure in longitudinal and cross section of the 5 1-16-in. all steel

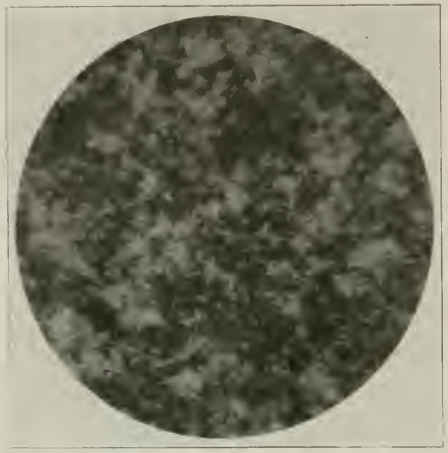


Fig. 9—Cross Section Showing Steel in ⅜ in. Copper-Clad Rod.
X 150

billet, after rolling to a ⅜-in. rod, and in Figs. 9 and 10 we have similar views of the steel in the ⅜-in. copper-clad rod, all at exactly the same magnification, ×150. The difference in structure, and the relative coarseness of the all steel rod as compared

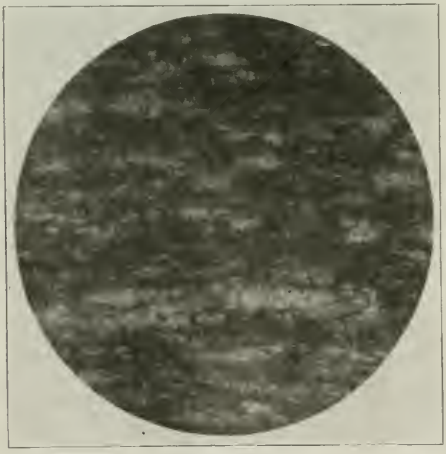


Fig. 10—Longitudinal Section Showing Steel in ⅜ in. Copper Clad Rod.
X 150

with that of the copper-clad is at once apparent.

To still further emphasize the fineness of grain of copper-clad, and the profound influence of the copper upon it, compare the structure of the steel in Fig. 11, which is a micrograph of the steel in 3 13-16-in. copper-clad bar with that of the ⅜-in. bare steel rod, both at the same magnification, and note that the grain of the copper-clad is but little coarser than that of the bare steel rod, yet the one is ten times greater in diameter than the other. Further examples of these differences in structure are to be seen in Figs. 12, 13, 14 and 15, which are longitudinal sections respectively of the steel in No. 2 B. & S. gauge copper-clad, and No. 6 iron gauge galvanized steel, B. B. and E. B. B. wires at a magnification of 200.

Copper and steel in the presence of moisture form a couple and the rusting of the steel proceeds with great rapidity. The resistance to corrosion of copper-clad, so far as the copper coating is concerned, is, of course, the same as that of copper; but, in view of the marked galvanic action set up between copper and steel, it would be assumed that corrosion would quickly occur at the exposed ends and be a constant and active factor so long as an electrolyte was present, and that this factor would be the more active at the point of union of the two metals than elsewhere. This supposition is not so, for tests on copper-clad rods have shown that when corrosion is set up it begins at the centre of the steel instead of at the point of contact of the two metals; while with a copper tube shrunk on a steel rod, exactly the reverse is true. These conditions

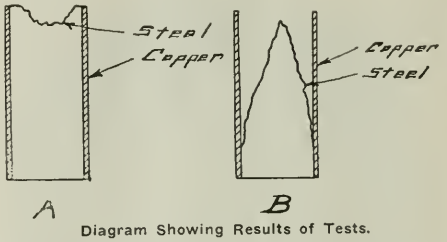


Diagram Showing Results of Tests.

may be illustrated diagrammatically in which A is a section of a copper-clad rod and B is a copper covered rod. In A corrosion sets up at or near the center of the steel, and proceeds more or less slowly towards the copper, being the more active at the centre of the steel and less active at the copper contact and forming a crater-like cavity as shown. In B corrosion sets up at the point of contact with the copper and proceeds more or less rapidly along this contact, and through the steel until the latter is gone. This phenomenon may be explained on the ground that in copper-clad there is a definite union of the copper and steel, and that certain of the products of this union possess properties which retard ironization, and do not accelerate corrosion.

In the copper covered rod there is no definite union of the copper and the steel, and hence no compounds can be present, and the differences in polarity and potential between copper and steel furthers ionization and accelerates corrosion.

The uses to which copper-clad steel may be put are many. The most obvious is a wire to be used for elec-

trical and mechanical purposes. The conductivity requirements for electrical use depend directly upon the amount and kind of copper used in the coat. Thus, a copper-clad wire four-tenths of whose sections area is copper, will have a conductivity as shown in Table I.

In other words, copper-clad steel electrical wire has an average conductivity of 40 per cent of the same size copper wire. In telephone work the life of the line is dependent upon its breaking and elastic limit. These are for a No. 10 copper wire respectively 530 and 293 pounds, while that of a No. 14 copper-clad is 760 and 320 pounds. The one weighs 166 pounds per mile and the other 61.

Comparing copper-clad with galvanized iron tele-

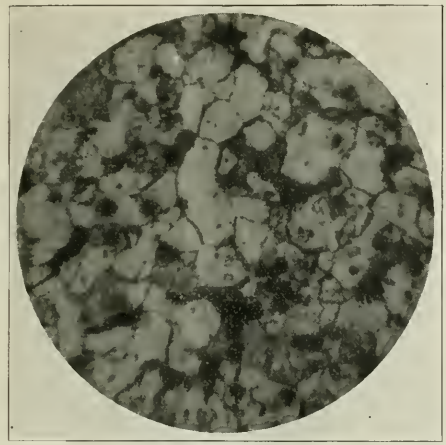


Fig. 11—Cross Section Showing Steel in 3 13/16 in. Copper-Clad Bar. X 150

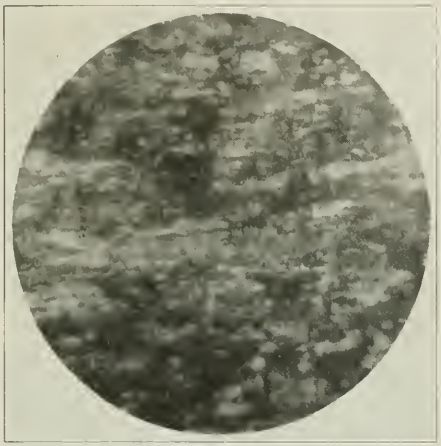


Fig. 12—Longitudinal Section Showing Steel in No. 2 Copper Clad Wire. X 200

B. & S. Gauge Number.	Weight of Pounds Per 1,000 Feet. Copper-Clad.	Copper.	Av. Resistance Int. Ohms Per 1,000 Ft. at 60° F. Copper-Clad.	Copper.	Area in Sq. Inches $D^2 \times 7854$.	Reciprocal of Area. $\frac{1}{A} = R.$
0000	594.5	639.8	.1202	.04906	.16619	6.0172
000	471.4	507.3	.1516	.06189	.13177	7.5891
00	373.9	402.4	.1912	.07803	.10452	9.5675
0	296.6	319.2	.2408	.09831	.082907	12.062
1	235.1	253.0	.3040	.1241	.065733	15.213
2	186.4	200.6	.3835	.1565	.052117	19.187
3	147.8	159.1	.4832	.1972	.041331	24.195
4	117.3	126.2	.6095	.2488	.032781	30.505
5	92.92	100.0	.7688	.3138	.025987	38.481
6	73.73	79.35	.9690	.3955	.020612	48.515
7	58.50	62.96	1.221	.4986	.016354	61.147
8	46.39	49.92	1.540	.6288	.012969	77.109
9	36.77	39.57	1.944	.7934	.010279	97.288
10	29.17	31.39	2.449	.9996	.0081553	122.62
11	23.11	24.87	3.092	1.262	.0064611	154.77
12	18.34	19.74	3.898	1.591	.0051276	195.02
13	14.56	15.67	4.908	2.003	.0040715	245.61
14	11.54	12.42	6.190	2.527	.0032271	309.88
15	9.160	9.858	7.802	3.185	.0025607	390.52
16	7.250	7.802	9.855	4.022	.0020268	493.38
17	5.765	6.204	12.39	5.059	.0016117	620.46
18	4.562	4.910	15.66	6.392	.0012756	783.97
19	3.621	3.897	19.74	8.057	.0010122	987.92
20	2.877	3.096	24.83	10.14	.00080425	1243.4

phone wire, a much smaller sized copper-clad may be used for the same ohmic resistance, thus:

Wire.	Diam. in Inches.	Ohms Per Mile at 68° F.	Weight Per Mile Pounds.
E. B. B.	0.134	18.83	250
B. B.	0.134	22.04	250
Copper-Clad	0.134	7.50	266

Both copper and steel posses certain disadvantages for line work. Copper has a low elastic limit and a

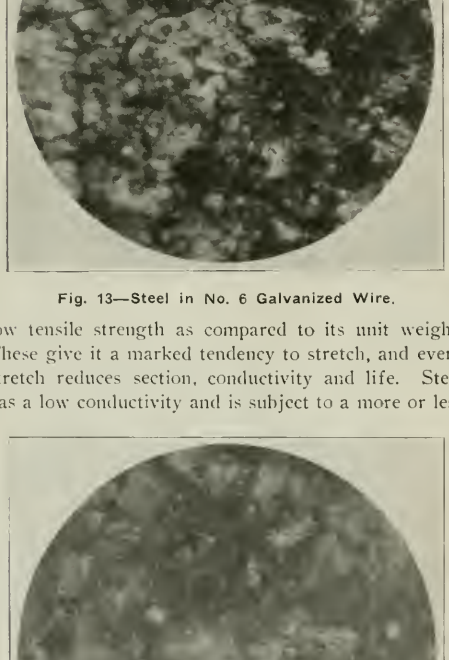


Fig. 13—Steel in No. 6 Galvanized Wire.

low tensile strength as compared to its unit weight. These give it a marked tendency to stretch, and every stretch reduces section, conductivity and life. Steel has a low conductivity and is subject to a more or less

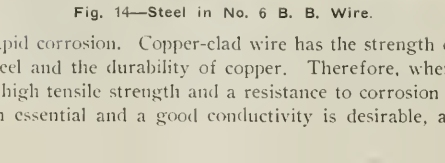


Fig. 14—Steel in No. 6 B. B. Wire.

rapid corrosion. Copper-clad wire has the strength of steel and the durability of copper. Therefore, where a high tensile strength and a resistance to corrosion is an essential and a good conductivity is desirable, as, for example, in power transmission requiring long spans, its value is apparent.

For mechanical purposes, such as bridge work, derrick guys, rigging, springs, rounds of all sizes suitable

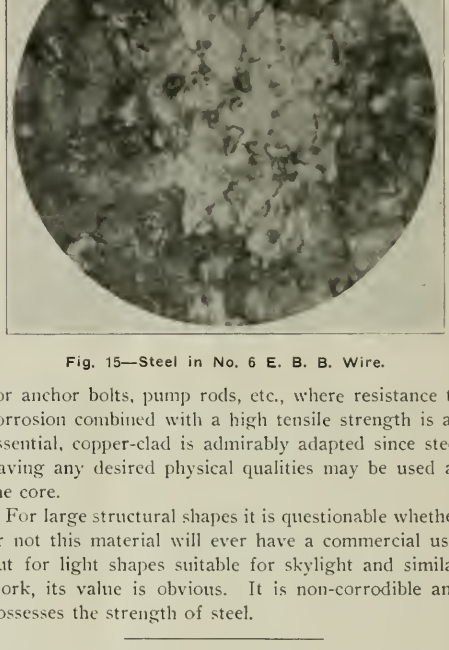


Fig. 15—Steel in No. 6 E. B. B. Wire.

for anchor bolts, pump rods, etc., where resistance to corrosion combined with a high tensile strength is an essential, copper-clad is admirably adapted since steel having any desired physical qualities may be used as the core.

For large structural shapes it is questionable whether or not this material will ever have a commercial use, but for light shapes suitable for skylight and similar work, its value is obvious. It is non-corrodible and possesses the strength of steel.

In a paper used before a meeting of the Geological Society, at Washington, D. C., it was stated that platinum occurs in peridotite dikes of the enstatite-mica-picrite variety at the Key West and Great Eastern prospects in the Copper King district, Clark county, Nevada. The properties are situated in the rough foot hills of the Virgin range at an elevation of approximately 3,600 ft. and are 8 or 9 miles from the Virgin river. The rocks in the immediate vicinity are gneisses, probable of pre-Cambrian age, and are intruded along the planes of schistosity by basic dikes which contain, in addition to platinum, primary pyrrhotite (probably nickeliferous), magnetite, chalcopyrite and pyrite. Besides the periodotite dikes there is also present a typical hornblendite dike which shows upon analysis a trace of platinum. Alteration and concentration of the sulphides in the rock by solutions seems to increase the percentage of platinum and nickel, one analysis showing the presence of 0.55 of an ounce of platinum per ton and over 5 per cent nickel. The dikes as exposed upon the surface vary in width from 10 to 50 ft. and are about 100 ft. long. One carload of ore has been shipped from the Key West workings.

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NOTES AND COMMENTS.

The San Francisco Meeting of the American Chemical Society.

Attention is directed to the report, in another column, of the trip of the eastern chemists to the forty-second general meeting of the American Chemical Society, held at San Francisco July 12th to July 19th. Professor McCormack attended this meeting to report its activities and to obtain papers, presented there, that may be of interest to readers of THE CHEMICAL ENGINEER.

Just before reaching San Francisco the special, with the editor and other members of the American Chemical Society en route to the general meeting, was derailed, and while none of the passengers were severely injured all were badly shaken.

Standard Methods of Analysis.

The summer meetings of our societies are on. We note the American Institute of Chemical Engineers at Niagara Falls, the American Society for Testing Materials, at Atlantic City, and the American Chemical Society at San Francisco. We have a marked and definite advantage from the free interchange of ideas which comes about on these occasions. Methods of analysis are being standardized through committees of societies and not only are the best methods being picked out but the standardization in itself is of great value.

Every chemist knows that many of his determinations can only be approximate and that his method may largely determine results. In such cases it is a great satisfaction to know at least that all who are working on any particular determination are obtaining comparative results. The object sought in many cases is simply the testing of the quality of a product and while we should never forget that an ideal determination is accurate, yet the value of standardized approximate methods is unquestionable.

The comparison of results on samples of various materials sent out by the committees of these societies is cleaning up many difficulties and annoyances which beset the industrial analyst. It is making for more efficient work for the chemist and manufacturer as well.

Not alone in methods of analysis are improvements being made, but also in forms of apparatus for conducting these methods. Recently we were surprised to see the results of an extensive research on the ordinary sulphur determination. We thought that that determination was one of the well established ones among all our standard types. Greatly to our surprise we found that many of our conclusions were based on erroneous ideas.

Recently we notice that a firm supplying laboratory materials has put on the market a crucible which is a modification of the standard Gooch type, which, however, requires neither felt nor asbestos.

Our manufacturers and supply houses are deserving of praise for their desire to aid us by bringing out new types of apparatus. Too little attention has been given to this phase of analytical work in the past.

The Federal Bureau of Mines.

The act establishing a Bureau of Mines in the Department of the Interior became effective July 1st. The entire Technologic Branch of the United States Geological Survey, including the mine accident investigations, fuel investigations, the entire personnel, property and equipment has been transferred to the Bureau of Mines. The structural materials investigations, including the personnel and equipment for these investigations, were transferred to the Bureau of Standards, Department of Commerce and Labor. The fully equipped testing station at Pittsburg also goes to the Bureau of Mines. The law creating the bureau provides for a variety of problems other than the mine accidents and fuel investigations, that properly belong to the Bureau of Mines, such as methods of mining and metallurgical processes. But these activities will be deferred for the most part until adequate appropriations are authorized. The work of the Bureau of Mines for the first year will be a continuation and expansion of the work carried on by the Technologic Branch of the Geological Survey. The mine accidents investigations will be considered as urgent and will be the feature of the work.

Of the money appropriated for mine accidents investigations, it is interesting to note that $40,000 have been allotted to the investigations of explosives; $10,000 to ore treatment; $100,000 for analyzing and testing of the coals, lignites, ores and other mineral fuel substances belonging to or for the use of the United States. Of this latter amount $35,000 will be spent in the chemical and physical investigation of fuels; $22,000 in fuel efficiency investigation; $5,000 in lignite and peat investigations; $4,000 in bricketting investigation, and $25,000 in the inspection of government fuel purchases.

Since the establishment of the mine experiment station in Pittsburgh, during 1908, considerable progress has been made there by investigations of explosives, coal gas, dust, electricity, and other possible causes of mine explosions. Considerable progress has also been made in the investigation of explosives used in coal mining and the conditions under which they may be

used with the least risk. The fuel investigations have already resulted in a better realization throughout the country as to the value of fuels. One result of this work is that nearly all of the fuel now purchased by the federal government is bought on specifications and subpect to test by the fuel division, or purchased after examination made of the coal supplied by the mines from which coal is delivered to the government.

The statement above has been abstracted from a notice issued by the acting director of the Bureau of Mines, together with the statement that the Bureau is about to make up a permanent mailing list of those interested in receiving news items concerning its work. If you care to have your name on such lists notify the director of the Bureau of Mines, Washington, D. C.

Chemists and chemical engineers will view with approval the establishment of this Bureau.

The results of its investigations will be important contributions to the science of applied chemistry. It is to be hoped that its investigations will be in no way hindered, and that the government by generous appropriations will make it of the utmost value to the nation.

THE EXCURSION OF THE EASTERN CHEMISTS TO THE 42D GENERAL MEETING OF THE AMERICAN CHEMICAL SOCIETY AT SAN FRANCISCO.

(EDITORIAL CORRESPONDENCE.)

The journey made by the eastern chemists to attend the meeting of the American Chemical Society in San Francisco is, we are sure, unique in the annals of the society.

The Eastern and Southern members of this society gathered in Chicago on July 4th, where they were entertained by the Chicago Section at the Hotel La Salle. Boarding a Santa Fe train on the evening of the 4th they started on their trip for California. The first stop was made at Colorado Springs, where the members of the party ascended Pike's Peak on a special train, and afterwards were taken to the Garden of the Gods and to visit other points of interest around Manitou and Colorado Springs. Colorado Springs was left the afternoon of the 5th, the next step being made at Adamana; the party here were loaded into spring wagons and lumber wagons, a new experience for most of our city members, and were driven about seven miles, over sandy roads and under a burning sun, to the petrified forests. The party found the forests of extreme interest. The conditions were quite different from those expected by the greater portion of the party, but the quantity of petrified material was much greater than we had reason to expect.

Returning to Adamana in the early evening, the party left for the Grand Canyon of Arizona. Our train was running ahead of schedule so we reached the Canyon in time to see the sunrise, a most beautiful sight. We also had time to remain until sunset. The day was spent by many members of the party in taking trips to various points from which different views of the canyon could be obtained. Only a few members of the party ventured to descend into the canyon and they only to one-half its depth. It is reported that the temperature was about 130 and as the only way of going down into the canyon is on burro back, the explanation why so few of the party took the trip is easy.

Leaving the Grand Canyon in the evening much of the Arizona desert was crossed during the night. Enough, however, was left that the party secured a good idea of conditions there during daylight of the next day. All of the accompaniments of the desert were present, the secretary of the society having arranged a mirage for the benefit of those members who had never seen one before. The party reached the orange groves of California at Redlands in mid afternoon, a great change from conditions previously prevailing. A drive was taken through the town of Redlands and the orange groves of that district. We then went on to Riverside and were driven around this city in automobiles.

The visit to these two cities gave the party a good idea of the method in which the orange is grown and handled in this section.

On Sunday morning the party reached Los Angeles, where they were delightfully entertained by the chemists of that city and the members of the Sierra Madre Club. The day was spent in visiting various points of interest around the city, and the evening at the quarters of the club. The next stop after leaving Los Angeles was at Lang, from which point we were taken, on the private railroad of the Sterling Borax Co., to visit their mine located near here. This is the largest borax deposit in the world, and having passed the development stage is now being put in most excellent condition for work. Only a small quantity of the product is concentrated at the mine, the greater portion being shipped to San Francisco and Chicago for treatment. The courtesies extended by Mr. Mather and Mr. Thordildsen were very much appreciated.

Lang was left about noon on Monday, the party proceeding to Santa Barbara. Here a delightful ride was taken to the old San Gabriel Mission, probably the largest mission in California and the one in the best state of preservation. At this place are buried many of the old Spanish governors of California. Leaving the Mission a delightful ride was taken along the beach and through the beautiful residence section of this city.

The schedule of the party called for a stop at San Jose at noon of the next day. This was interfered with, however, by a wreck of our train in the early morning. While none of the members of the society were seriously injured, they all felt as if they wanted to reach San Francisco where they could rest quietly for a time. The visit to Palo Alto and Leland Stan-

ford University was, therefore, postponed to a later date.

The part making the trip from Chicago was made up of about 75 members of the society, many of them accompanied by their wives, members of their families or guests. This trip we are sure has done much to promote acquaintance among the members of the society living in the Eastern and Central portion of the country.

THE SECOND SEMI-ANNUAL MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The second semi-annual meeting of the American Institute of Chemical Engineers was held at Niagara Falls, Ont., June 22 to June 24, 1910. There was a good attendance of members and many interesting papers were read. The address of President Charles F. McKenna was on the subject "The Study of Materials as a Subject in a Course of Chemical Engineering." In the address Dr. McKenna called attention to the fundamental importance of a thorough knowledge of all the properties, both physical and chemical, of the materials available for human use. The extraordinary number of substances used in the arts is surprising. A careful list of those used by one company comprised no less than 850 definite and distinct classes or grades of materials. He stated that the chemical engineer must study the properties of these materials because it is he who must transform the raw properties of nature into products possessing properties which make them of use to mankind. A careful classification of the tests, both physical and chemical, to be applied was given. No material, even the most common, has as yet been fully investigated and all of its properties discovered. He stated that the adoption of the so-called standard or uniform methods of analysis is apt to discourage rather than encourage the investigation of the properties of materials.

Short abstracts of other papers presented at the meeting follow:

CHANGES IN INDUSTRIAL CHEMISTRY CAUSED BY ELECTRICITY.

By Edward R. Taylor, Penn Yan, N. Y.

This paper called attention to the advantages to be derived from the use of electricity with the object of stimulating the development of water powers. The great advances already made in a number of industries, especially metallurgical and in the production of alkali and bleach, were reviewed, and it was shown that these industries could be carried on commercially only after water power is developed. The electric separations and determinations of metals now carried on only in the quantitative laboratory indicate what may be accomplished on an industrial scale in the near future. The manufacture of chlorine and ozone in small units indicate how many small industries can install their own plant for using chlorine and ozone for bleaching, cleaning, disinfecting, etc. Among the new uses for electricity was mentioned the very marked increased in the quality and quantity of yield of various agricultural products when electricity was allowed to leak into the soil. Twenty-four electric furnaces for the smelting and refining of iron and steel are at present in operation. The large amount of water power which is allowed to go to waste at present was deplored.

THE DEVELOPMENT OF CHEMICAL INDUSTRY IN CANADA.

By Judson A. DeCew, Montreal, Can.

This paper treated of the various industries of a chemical nature that are established in Canada, and showed, where statistics or dates are available, the rapid development that has taken place in this field within the last 5 or 10 years. An attempt was made to give the location of the various works and where possible the approximate capacity at the present time. The industries mentioned and concerning each of which some facts were given, were as follows: Eulphuric Acid and Alkali. Coal Tar and Ammonia. Explosives. Fine Chemicals. Wool Distillation Products. Petroleum, Salt, Milk, Sugar, Starch, Rubber, Glue. Paints, Fertilizers, Glass, Beverages, Soap and Glycerine. Calcium Carbide and Electro Chemical Products. Wood Cellulose products. Portland Cements. Reference was also made to several new projects that are still in the stage of development, but which may soon be classed amongst the established industries.

UNDERGROUND WATERS FOR MANUFACTURING PURPOSES.

By W. M. Booth, Syracuse, N. Y.

The paper gave reasons why underground water is or should be sought, also what preliminary steps should be taken in locating the wells, well surveys and records. The cost of drilling was discussed and the employment of a drilling company considered. The importance of the chemist as an aid in well drilling and the quality of water to be expected from different strata was also discussed. Examples were given showing methods and cost of pumping. The quality of water found in average wells at different depths and cost of treating well waters for manufacturing purposes was likewise fully discussed.

PLANT DESIGN.

By W. M. Grosvenor, New York.

In this paper a number of very practical suggestions were made with reference to plant design. Illustrations were given showing the advantage of handling materials by the gravity system. The installation of complicated systems of conveyors was declared to be generally poor policy on account of the usual high cost of maintenance. The importance of careful management of materials in construction work was emphasized. A loss of $10,000 work of material was reported in one case on account of poor storage facilities during construction.

NITRIC ACID.

Schuyler Frazier, Chicago, Ill.

This paper gave a few notes with reference to the

manufacture of nitric acid. The various important advances which have been made in recent years was reviewed, and the advantages secured by each improvement noted. Tables giving the yield and purity of acid obtained as well as rate of distillation were appended.

PROBLEMS IN CHEMICAL INDUSTRY.

By John T. Baker, Phillipsburg, N. J.

In this paper the author pointed out that the number and complexity of the factors involved in chemical operations are so great that many operations are still carried on under the rule of thumb guidance and have not been reduced to a science. On the other hand the trained scientific man is very prone to believe that the matter with which he deals will follow the laws which he has learned and for this reason he often overlooks valuable facts which the untrained observer sees. The untrained observer ignores laws and systems; tries any suggestion that comes along and therefore loses much valuable time and labor. The investigator who is successful follows a mean between these paths. A number of practical illustrations of these principles were given.

COMMERCIAL CALCIUM HYDRATE—ITS MANUFACTURE AND USES.

By Lucius E. Allen, New York.

This paper gave an outline of the method of manufacture of this product and called attention to the many cases in which it can be used to better advantage than the unslacked lime. It is well adapted for waterproofing Portland cement. Its keeping qualities are excellent.

NOTES ON THE CORROSION OF IRON AND STEEL AND ITS PREVENTION.

By Gustave W. Thompson, Brooklyn, N. Y.

This paper gave a most excellent summary of the facts which have been discovered with reference to the cause and prevention of the corrosion of iron and steel. The author leaves it to the reader to interpret these facts in the terms of any theory with which he may be familiar. The general conditions conducive to the formation of rust were first given. The opinion was given that facts do not warrant the conclusion that the tendency of iron to corrode is dependent on the composition of the metal and that the use of a poorer and more expensive metal as against a more impure and cheaper metal was not justified by the facts. Practical suggestions with reference to the prevention of corrosion of iron and steel were given, among which the following may be mentioned: The action of acids, moisture and oxygen. Cement prevents corrosion because it is alkaline. Protective coatings exclude moisture and oxygen. The cleaning of iron and steel before painting is of great importance. Specific rules for the cleaning of steel and iron are given as well as the value of the various methods in common use.

The principles which should guide in the selection or designing of the paint were given. Poor workmanship in the application of paint was given as responsible for most of the failures in the protection of iron and steel with paint. Linseed oil was condemned as a prime coat for iron and steel. Nineteen different paints applied to the Harve de Grace Bridge of the Pennsylvania railroad all proved equally effective because they were properly applied. Oxygen cannot be excluded from iron by means of any protective coating. In the absence of moisture, oxygen does not produce corrosion.

In addition to the above, papers were also presented by Dr. Oscar Linder of Chicago on "The Manufacture and Industrial Application of Ozone"; by A. Bement, Chicago, Ill., on "Coal: Its Deterioration in Storage," and by Dr. F. G. Wiechmann on "A New Product for Use in the Arts." These three papers will be reprinted in early issues of THE CHEMICAL ENGINEER, and it is also hoped to reprint in full some of the other papers of which abstracts have been given.

The small coal from the bituminous seams which overlie the steam measures in South Wales is used largely for the production of coke. Irrespective of that made in gas works the coke manufactured in the Welsh coal field totals 1,470,000 tons per annum. During the past decade important improvements have taken place in the coking plants. By-product ovens are becoming the rule throughout the coal field, and the detailed treatment of the tar and ammoniacal liquor collected in the process is now being carried on by some of the larger companies. The gas driven off from these coke ovens is in some cases utilized to run gas engines for the generation of electrical power. At one group of collieries, now being opened out, it is proposed to eliminate the steam boiler and run the whole of the winding, ventilation, pumping, haulage, and other work by electricity generated from coke-oven gases. The coke produced at the Welsh collieries is mainly used at local iron and steel works. The surplus left for export is small, the annual shipments from the port of Cardiff not exceeding 100,000 tons. This is the only district in Great Britain in which the manufacture of briquettes assumes important proportions. The total annual production in South Wales is 1,500,000 tons, practically the whole of which is exported. The average price of briquettes f. o. b. Cardiff in 1909, was $3.65 per long ton.

Consular Agent John B. Brewer of Wiesbaden, Germany, reports that a civil engineer, having his experimental plant in the Wiesbaden district, has found and patented a very simple process for extracting, at little expense, all water from peat. The freeing from water is accomplished by the admixture of peat-coke to the peat before pressing in the proportion of 1 to 15. As no extraneous substance is used, there is complete independence from other ingredients. The pressing proper is done by specially constructed and patented machinery of a simple kind.

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THE ARTIFICIAL SILK INDUSTRY.*

By W. P. DREAPER, F. I. C.

In the French Exhibition of 1889 Count de Chardonnet exhibited his now well-known process of manufacturing filaments of nitrocellulose by squirting collodion under suitable conditions into the air. The progress from this early production of highly inflammable filaments, to the present production of the large output of artificial silk manufactured by this process, which exhibits none of these inflammable properties, and resists the disintegrating action of water has been achieved by careful research. Today the production of the material by the original method, starting with a solution of guncotton, has met with signal success; and even in the absence of any competing process would have led to the building up of an industry of a permanent nature, from which the textile industry generally would have derived much benefit. This process of manufacture may in time go the way of most original processes, and give way to the more direct methods of later date. At present it is responsible for about 50 per cent of the world's output. I have been informed in the Elberfeld-Barmen district, where 500,000 kilos are worked up every year, that for some manufacturers the nitro-product is absolutely essential, while for others the newer products are of more value.

If time proves that this is a normal condition, then the mere cost of production will not be the only determining factor in the situation.

Anyway it is patent to all those interested that great economies have been effected in this process, more especially in the recovery of the solvents, and their reuse; in the rapidity of production, and in other ways of which no one outside the actual works can have definite knowledge.

Of the processes which have survived to this industrial stage, the three systems called, respectively, the nitro-cellulose, the cuprammonium, and the viscose ones may be specially mentioned. These have been so controlled that they now produce a marketable product, which is in such demand that delivery can only be obtained for the second half of next year at the earliest. This latter point is an important one, for it is an indication that the newly founded industry is based on a genuine demand.

These yarns, which range in size from 100 deniers upwards, are not adapted to the manufacture of such materials as are prepared from ordinary silk fibres of from 15 to 32 deniers, or even upwards; but they enter into a whole range of articles, and have had a profound influence on certain manufacturers, such as the braid industry, and given employment to a large number of hands.

The new uses which are being found almost daily for these products also indicate a steady and increasing demand for the yarns in the future. For example, it is possible to manufacture a heavy cloth from these high denier yarns.

The early samples of the nitrocellulose product were extremely brittle and inflammable, and lost 50-70 per cent of their strength on wetting. They were, however, extremely brilliant, and this satisfactory factor certainly led to further research and improvements in other directions, which gradually decreasing these objectionable features, caused such a demand for the yarn in comparison to the possible supply, that the price of this artificial silk for a time actually exceeded that of the real material. The extreme brightness of the goods made from it, and their peculiar feel, was undoubtedly the cause of this. With this state of affairs there is no wonder that the industry in France and Germany expanded, and several companies were undoubtedly formed to work process which had little chance of commercial prosperity. The patent list of these times also indicated the gradual expansion of the experimental work which naturally followed, and was destined to give to these countries an absolute monopoly of manufacturing, which they have held to all purpose until the last year or so; and also to give to the textile manufacturers of these countries a first call on this important and novel product.

The absence of the yarn itself in this country was one of the chief factors causing our neglect of this matter. The many difficulties of the process were emphasized by the failure of the English company (starting to manufacture under the Chardonnet rights) due, it was then said, to local atmospheric conditions, the actual solution prepared in France refusing to spin at the Coventry factory.

Dr. Lehner demonstrated his process in London, but it was in Switzerland that he built up the enormous business which is associated with his name, and which today turns out such large quantities of the nitro-product. Chardonnet had to work with very high pres-

*From the Journal of the Society of Chemical Industry.

sures, but Lehner, by modification of the solution, was able to squirt at very low ones. He also squirted into water, and in this way recovered the major portion of the solvent. The threads of nitro-cellulose were wound on to bobbins and dried.

Factories producing such a product were destined, sooner or later, to come under the notice of the insurance companies. Serious fires took place, and were unpreventable. It was found that the nitro-cellulose yarn in the dry state, like silk, became highly charged with electricity, and that self-ignition took place. The risks were subsequently modified by keeping the yarn in a wet state until it entered the "dentifrying" bath. There was still the alcohol-ether to be reckoned with, and it is, I believe, still impossible to insure such a factory.

This mattered little, however, to companies making such profits. The Tubize Company rebuilt part of its factory a few years ago out of the year's income and still paid a good dividend.

Great speculation in shares; high and fluctuating prices for the yarn; fire at the works—but, most important of all, an increasing demand for the product, characterized the early days of the industry, the slow and steady progress of which was assured and never in doubt.

HISTORY OF THE INDUSTRY.

In 1855 the well-known French investigator, Reaumur, suggested the production of what might be termed artificial silk, and in 1885 Andemars patented the production from a nitro-cellulose base, but nothing more was heard of the process. In 1884 Count de Chardonnet deposited with the Academie des Sciences a sealed document which was opened on Nov. 7, 1887; it bore the title, "Sur une matière textile artificielle ressemblant à la soie." He had sufficiently worked out his process of manufacture to obtain a Grand Prix at the Paris Exhibition of 1889 for his product. He lodged his first patent on Nov. 17, 1884 (Fr. Pat. 165,349). The first apparatus actually used for trials is shown in a photograph published in a work published by T. Foltzer in 1903 (Fabrication de la soie artificielle parisienne).

In 1889 De Vivier produced a product termed "Soie de France," but except in small details the production, and product, was very similar to that of Chardonnet process (Fr. Pat. 221,901. May 25, 1892).

As a result of these early inventions the following centres have produced this nitro-cellulose product in large quantities. Works at Besancon, in France; at Tubize and Droopgenbosch-Ruysbrock, in Belgium; at the four factories of the Veroinigte Kunstseide Fabriken, of Frankfort; at Kelsterbach, S. M.; at Robingen, near Augsburg; Glattsbrugg and Spreitenbach, near Zurich; at Padua, in Italy, and in Hungary.

The first patent connected with the production of artificial silk from cellulose dissolved in a cupro-ammonia solution was that of Despeissis (Fr. Pat. 203,741, Feb. 12, 1890). The only remaining record of this appears in a French publication, as under the French law of that date the specification was not printed, and being abandoned, owing, I believe, to the untimely death of this investigator, is not available for reference. Nothing more was heard of this process until Pauly in 1897 patented a process on very similar lines. The English specification has since been restricted by amendment so that the original suggestion of Despeissis, viz., the addition of a proportion of some albuminoid substance to the solution, has been omitted in the latter specification.

In 1889 (Eng. Pat. 6,556, 1899), Fremery and Urban took out their first patent, dealing with details in the manufacture. In the same year (Eng. Pat. 18,260, 1899), Bronnert patented his first improvement in connection with the direct solution of cellulose, although he had previously, in 1886 (Eng. Pat. 6,858), taken out a patent for improvements connected with the nitro-cellulose process.

Pauley, Bronnert, Fremery and Urban are forever associated with the industrial application of the copper ammonia process on the large scale; they have through their investigations led to the development of the celebrated Glanzstoff Company, which today employs over 7,000 hands, and manufactures such large quantities of this product. Their headquarters are at Elberfeld, and their works are at Niedermorschweiler and Oberbruck in Germany; they are also interested in works at Givet, and at Izieux, in France (Messrs. Gillet et Fils). I believe that a Spanish company, the Sociedad Espanola de seda Parisien, has ceased working. The British Glantzstoff Co., Ltd., has recently started works at Flint, which it is said will give ultimately employment to 2,000 hands. It is understood also that works will shortly be erected in Russia.

In 1902 Thiele took out his first patent for improvements which enabled much finer filaments to be spun than heretofore.

This and subsequent patents suggested a possible development in the industry (Fr. Pat. 320,446) in competition with the natural article.

Since that date the patents registered in connection with this copper-ammonia process have been very numerous. Only time will demonstrate their respective merits. In some cases copper carbonate in ammonia is used to dissolve the cellulose. Many patents deal with the use of different precipitating solutions, and details in the process, such as, for instance, the preliminary mercerizing of the cotton.

In the early days there were in this country several investigators of note working on the subject of artificial filaments, amongst whom may be mentioned Crookes, Swinburne, Wynne and Powell, and Swan; also the first patent for a direct process of manufacturing from cellulose was taken out by two Englishmen in 1884. It was not until six years after this date that Despeissis took out his first patent, which formed the basis for the early working of the cuprammonium process. It remained for France and Germany to bring this industry to a successful issue. However, having recently reached a state of manufacturing ef-

ficiency, as at the Coventry Viscose Works, we have made up for lost time.

It was natural that France, with the silk work industry so firmly established in the south, should look with greater interest upon the possible manufacture of an artificial product, which might supplement the natural supply.

The fact that Pasteur was instrumental in saving that industry from decay may also have had an influence in intensifying the belief that the problem was capable of commercial realization through the aid of scientific research.

PROCESSES OF MANUFACTURE.

Chardonnet Process.—The original plant at Besancon started with an output of 50 kilos. a day in 1891; it had reached 1,500 kilos. in 1904, and 1,800 to 2,000 kilos. in 1907, and seems to remain at that figure in 1909. The breaking-strain is given at 1.5 grms. per denier, and the elasticity at about 15 per cent. Whether elasticity is quite the term to use in the case of artificial silk is perhaps open to question. It is doubtful if the "stretching before breaking" which takes place can be compared with the actual elasticity of the real fibre.

Great precautions are necessary in the production of the solution of guncotton. The polariscope is used in determining the correct state of solution. The jets through which the collodion is squirted are accurately regulated by micrometric measurement. The process of denitration is, of course, a reducing one, and the details remain a secret. Temperature of the bath is a consideration, and the great aim is to reduce the loss of strength to a minimum. Years of study have greatly improved this operation, and have produced a thread which varies very little in this respect from day to day.

The statement is made that in 1907, 2,500,000 litres of alcohol were consumed in the Besancon works, so that each kilo. required between 4 and 5 litres of alcohol in its manufacture. A kilo. of 100 denier thread of this silk contains 90,000 metres in length, or nearly two million metres of single filament as squirted from the jets. The selling prices of this product has been given as 30 fr. per kilo. in 1896, 26.50 fr. in 1897, and 21.75 fr. in 1898; in 1903 it reached the price of 40 fr. per kilo., and it may be taken at 20 fr. today.

Zinc Chloride Process.—The first patented invention dealing with the production of artificial filaments by the direct solution of cellulose in aqueous solution and without the intervention of the nitrating process was made by Wynne and Powell in 1884 (Eng. Pat. 16,805 of 1884). These investigators seem to have confined their attention to the industrial production of electric light filaments, and this process has proved itself of great value in this direction and is in use today.

In conjunction with H. K. Tompkins, I took out further patents in 1897 dealing with details. In one of these patents the advantage obtained by "drying of the fibres or threads in a considerably stretched condition" was emphasized. This practice has since found a place in all the artificial silk process dealing with the direct solution of cellulose which have since reached the industrial stage; and without it, it is impossible to obtain yarns of the maximum brilliancy.

Bronnert in 1899 patented the preliminary mercerizing of the cellulose and claimed that the solution was correspondingly facilitated. A good deal of work was done in this country by the Cellulose Silk Syndicate, Ltd., in connection with this process, and also by Bronnert on the Continent; but in spite of statements to the contrary, I do not think that this process has ever been worked on a very large scale.

The Cupro-Ammonium Method.—As before mentioned this originated with the Despeissis patent (Fr. Pat. 203,741, Feb. 12th, 1890). Nothing was, however, done with the process until Pauly repatented the process in 1897 (Eng. Pat. 28,631 of 1897). The cellulose is dissolved in an ammoniacal solution of a copper salt. The details of this method are, of course, not made public, but after filtering a satisfactory solution may be obtained. The coagulating solution may be a 15 per cent solution of sulphuric acid, copper sulphate and ammonium sulphate being produced, and the cellulose is precipitated in the thread form, and wound on suitable winders, which are usaully made of glass. The newly-formed fibre is then washed on these holders with fresh water.

E. Bronnert (Eng. Pat. 18,884 of 1899) claims the treatment of cellulose with caustic soda, and then copper sulphate is added.

When ammonia is added to the resulting mixture of cupric hydrate cellulose and sodium sulphate, a solution of the cellulose is obtained. Many patents have since been taken out, and it is obviously impossible to disclose the exact procedure in any works, even if they are known.

The recovery of the solvent materials is mentioned later. Fremery and Urban have observed (Eng. Pat. 20,630 of 1899), that it is advisable to dry the product in two stages: First at 104° F., and afterwards at a higher temperature. If the yarn be submerged in water at a temperature of 158° to 212° F., they claim that dehydrating action takes place with beneficial results.

Viscose Process.—In the year 1892, Cross, Bevan, and Beadle (Eng. Pat. 8,700 of 1892) patented their method of bringing cellulose into solution for industrial purposes, but it was not until 1903 that Stearn (Eng. Pat. 1,020 of 1898), disclosed a commercial method of preparing filaments by precipitating this solution in the required manner by means of a solution of ammonium salts. This process was found to offer special difficulties, but today they have been overcome; and as a result of the initial work and first experiments at Kew, works have been erected at Coventry by Messrs. Samuel Courtauld & Co., Ltd., where this product is being produced in increasing quantity. The process is also being worked at Sydowsaue, near Stettin, in Germany (Kunstseide und Acetatwerke Furst Henckell Donnersmarck), in France, at Arc-la-

Bataille, near Dieppe (Societe Francaise de la Viscose), and in Italy.

Further important work has been done in this country on this process by Courtauld and Wilson (Eng. Pat. No. 21,405 of 1907), who suggested the addition of glucose to the precipitating bath, and Topham (Eng. Pat. 23,158 of 1900), who applied the turbine method of collecting the threads to these artificial fibres, an extension, I believe, of its previous use in the spinning of very short-fibred yarns, such as asbestoes. Many patents have been taken out by other investigators, which deal with the preparation of the solution, methods of squirting, and subsequent treatment of the yarn, but they are too numerous to mention here. It is interesting to note in passing that the jets used for squirting in this process are made of platinum.

An extension has been granted to the original inventors for their patent rights in this country, so that although the patent dates from the year 1892 the rights are still in operation.

Cellulose Acetate Process.—Several patents have been taken out in this direction, notably by the Bayer Co., the Badische Co., and the Donnersmarck Co. They chiefly deal with the control of the methods of preparing the cellulose acetate. The question of a suitable solvent seems to present a great difficulty, although it is stated that there are many derived acetates, and that some of these are soluble in alcohol, or pyridine; but chloroform seems to be the chief solvent.

Quite recently (Eng. Pat. 6,654 of 1909), it has been claimed that formic acid is a satisfactory solvent. If this is so, a distinct advance has been made.

Gelatin and Casein Processes.—Very little has been done in this direction from the commercial point of view. In 1897 Miller patented a gelatin process (Eng. Pat. 2,713 of 1897); in 1907 Mugnier used vegetable albumins with the addition of borax, and Jannin patented the use of a solution of gelatin, glycerin, and formaldehyde in 1904 (Fr. Pat. 342,112). Casein was used by Chatelineau and Fleury, Timpe and Todtenhaup, but little has been heard of the processes.

Recovery of Solvents.—The recovery of raw materials used as solvents is an important step in the nitrocellulose and copper-ammonia processes. It is, so far as I know, of small importance in the manufacture of viscose silk. In the first case, the recovery of alcohol, ether, or acetone from the air is important from the cost point of view, but is a difficult operation. Exactly what proportion is recovered in practice has not been disclosed.

Quite recently the Tubize Company have patented the absorption of the alcohol and ether vapour in sulphuric acid of 62° B. at 20° C.

In the copper-ammonia process both the copper and the ammonia can be recovered by known means.

When the precipitating liquid is of an acid nature, electrolytic methods are available for the removal of the copper, leaving the ammonia behind in solution. This solution may be used for manuring purposes, or the copper may be precipitated as sulphide.

Recently applications of the known reducing action of glucose has been brought forward in the case where the precipitating solution is of an alkaline or caustic nature. The addition of glucose to the precipitating bath throws the copper out of solution almost immediately, and the precipitating solution has a much longer life. This process works well in practice.

These few remarks will indicate some of the methods adopted in different cases, dealing with this important branch of the manufacture.

Machinery.—Each process has its special requirements as regards the machinery employed, and these have been naturally met in various ways. Companies working the same process in different countries differ materially in actual methods. In addition to this there is a mass of detail, which in many cases is not protected in any other way than that of secret working, and may be confined to the working of a single factory. Under these conditions I can only indicate one or two cases which may illustrate the methods adopted in the manufacture of these threads.

The first case is that of the original Chardonnet apparatus. This is of interest as showing in the original patent (Eng. Pat. 2,211 of 1886), the amount of detail already available in those early days. The thread passed from the jet, which had a bore of 1/20 to 1/5 m. m., through a very short column of water and then on to the winder. When a thread broke, the broken end was seized by pincers and carried over guides to the reel to be wound. The pinions still ascending are cleaned by a rapidly revolving brush, before they descend again to pick up any more broken ends. This movement is repeated several times a minute. Air heated to 85° or 90° F. is passed by supply and discharge conduits through the outer chamber. The vapors carried by the air might be "condensed and removed by cooling" and the air after warming returned to the apparatus. The so-called Topham turbine system of collecting and spinning the threads at the same time (Eng. Pat. 23,158 of 1900) is a good illustration of the methods adopted to overcome the difficulties in manufacture. The squirted thread passes over a roller and thence into a rapidly rotating box. The fibres or threads as they are fed in are twisted together and are caused by the centrifugal force to form a compact coil around the interior of the box and to be formed into hanks or skeins. If the boxes are deep, a longitudinal reciprocating movement can be given to either the box or the funnel to make sure of the even coiling of the thread in the skein form.

I have seen this apparatus at work on the Continent, and it certainly illustrates a very ingenious method of combining the skeining and twisting in one operation. It is, or has been, largely used in the manufacture of artificial silk. It reduces the strain on the newly formed threads to a minimum.

A third example is that of one of the more recent

patents dealing with modifications in the Thiele "two-solution" process of spinning. (Dreaper, Eng. Pat. 21,872 of 1908; see this J., 1909, 1,246.) In this case arrangements are made so that the freshly squirted thread comes in contact with a precipitating solution which acts comparatively slowly, and then passes into a stronger one.

PROPERTIES OF THE FIBRES.

Recognition of Artificial Silk Yarns.—The nearer these yarns approach real silk in their physical properties, the more important will it become to have a satisfactory method for distinguishing between them. The qualitative and quantitative estimation of these different fibres has been studied by Saget and Suvern (Bull. Soc. d'Encouragement, 1906, 540), in comparison with real silk.

The ash in these products is under 2 per cent. Natural silk contains 17 per cent of nitrogen as compared with the following figures for artificial silk:

Nature of Yarn.	Per Cent.
Pauly make (Cuprammonium)	.13
Chardonnet (Nitrocellulose) French	.15
Chardonnet (Nitrocellulose) German	.16
Lehner (Nitrocellulose)	.07
Nitrocellulose	9.15 to 14.14

It must therefore be the different state rather than the amount, in which the nitrogen is present in the (reduced) nitrocellulose products which determine its effect in dyeing with basic dyes, if this is the real cause of this phenomenon.

Diphenylamine sulphate is the ready test for artificial silk, and give the following reaction:

Silk—Brown coloration.

Tussah silk—Brown (intense).

Chardonnet and Lehner (Nitrocellulose)—Intense blue.

Pauly, Viscose or Yarmouth silks—No reaction.

Strength on Wetting.—This loss in strength has introduced a serious factor into the manufacture of textiles, but under present conditions this defect is gradually decreasing, and may in time be eliminated. This is seen by comparing figures published in 1900-1901 with more recent figures which are available.

In the year 1900 an insolated test (Bronnert, Bull. Soc. Ind. Mulhouse, 1900) gave a loss of 77 per cent for Chardonnet silk in strength on wetting.

In the year 1901 Strehlenert gave the following figures:

Yarn.	Dry strength.	Wet strength.	Loss per cent.
China silk	53.2	46.7	14.1
French (ecrue)	50.4	40.9	18.8
Chardonnet silk	14.7	1.7	89.6
Lehner	17.1	4.3	74.8
Viscose (old)	11.4	3.5	70.0
Viscose (new)	21.5	3.5	84.0
Glanzstoff	19.1	3.2	83.0

These figures give an average loss of 82.8 per cent on wetting for the artificial products.

In 1903 Hassack gave the figures, from which the strength per denier has been calculated, as follows:

Quality.	Denier.	Breaking strain in grms.	Breaking per denier in grms.	Elasticity. per cent.
Genuine silk	23	57.5	2.5	21.6
Chardonnet silk*	80	74.2	0.93	8.0
Fismis*	100	71.7	0.71	11.6
Walston*	120	151.4	1.26	7.9
Lehner	120	171.8	1.43	7.5
Pauly	120	197.6	1.64	12.5
Gelatine	100	63.0	0.63	3.8

*Nitrocellulose products.

Recent figures given by the testing department of the Manchester Chamber of Commerce show the following results:

Yarn.	Dry strength.	Wet strength.	Loss per cent.
Glanzstoff	92.5	31	66
Cellulo silk	75.5	33	56

According to these figures the Glanzstoff product now loses 17 per cent less "on wetting" than in 1901.

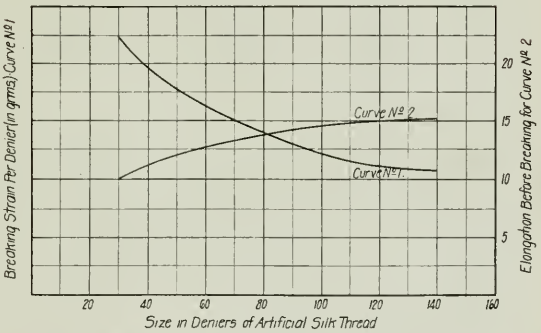


Diagram Showing Strength Factor and Size of Threads.

The strength (dry) is given by Cross and Bevan at 1.0 - 1.4 grms. per denier, against 2.0 - 2.5 grms. for real silk. I think this figure should now be extended to 1.6 grms. for the artificial silk product. The "extensibility under breaking strain" at 13 per cent to 17 per cent for the artificial product against 15 to 25 per cent for real silk. The average loss in strength on wetting is given at 70 per cent for all varieties (Escalier).

I have recently received a sample of a 25 denier artificial thread containing 60 filaments, which has a breaking strain of 58.5 grms. This shows a breaking strain of 2.3 grms. per denier. This is quite as strong as some natural silks. A pound of this silk would contain 176,000 yards, which would contain 10,560,000 yards of filaments, or six times the length which a corresponding weight of natural silk of the same size would contain.

Strength Factor and Size of Threads.—The accompanying diagram indicates for the same make of silk an

important increase in strength for the finer sizes per unit weight of thread (denier) and with it a decrease in "elongation before breaking." This latter figure does not mean that the elasticity is less. The fact that the number of filaments remains constant for the sizes tested is because the fibers are as nearly as possible made under standard conditions, and from the same solution of cotton. The results are shown in the curve from the actual figures obtained.

Dyeing Properties.—No two makes of artificial silk dye in exactly the same way. All the makes on the market dye with the direct, or cotton dyes, as might be expected. The general procedure is to dye at a low temperature, but I have seen artificial silk in mixtures dyed at the ordinary temperature for silk, after a "boiling off" in 1 per cent soap solution for 1½ hours. Ingrain colors do not seem to give fast results on this product; the reason for this is unknown. Difficulties have been experienced in dyeing some dark shades satisfactorily in the past, but these have been overcome.

The cellulose acetate product stands alone in its dyeing properties; it is stated that a dye-bath containing alcohol greatly facilitates this operation.

The nitro-product is not capable of standing the "Lancashire bleach," but samples of cellulo silk have stood it fairly well. Real silk would go into solution under the treatment.

Waterproofing.—The lack of strength in the finished yarn in the wet state has as mentioned been a source of great complaint in the past. Great improvements have taken place in this respect and there are indications that with time this defect may be altogether overcome. Naturally all manufacturers have been engaged in the problem of preventing this degradation of the fibre when wet, due to the hydration of the reprecipitated cellulose.

No known process of waterproofing by the application of waterproof materials in a suitable solvent is applicable, or of any real value. An attempt on altogether different lines has been made by Escalier (Monit. Scient., 1908, 13, and patents), who claim that he brings about a condensation of the cellulose molecule by treatment with formaldehyde. The recently published results of the strength of yarn in the dry and wet state, certainly indicates a specific action, and that this treatment reduces the tendency for the thread substance to return to the jelly state in the presence of water.

Some years ago the application of formaldehyde for this purpose was patented by Strelehnert (Eng. Pat. 22, 540 or 1896), but it was only claimed for nitrocellulose products and was applied to the solution of that substance before squirting.

The only alternative to some such process seems under present conditions to be the use of a raw material which will not hydrate in the presence of water. This material is undoubtedly present in acetylcellulose, and if the working of this material becomes amendable to commercial conditions, any special treatment will be unnecessary. However, cellulose acetate is so waterproof that it will not absorb dyes from aqueous solution. Silk itself has the advantage of not losing its strength in the wet state, yet it is easily dyed.

The loss in strength on wetting is a temporary defect. It is entirely regained on drying. For, example, fabrics of artificial silk and silk in mixture were boiled in 1 per cent soap solution for 1½ hours in order to discharge the silk gum from the silk. They have suffered little, if any deterioration from that process. Care is needed in the handling in the wet state, but it is not beyond the scope of modern dyeing and finishing to meet the necessary conditions, even with very fine counts.

Any further small reductions in the loss on wetting will materially decrease the difference which exists today between the relative strength of these yarns and silk, and bring nearer the time when they may be equal in this and other respects.

Scroup.—The peculiar rustle which silk possesses when dried out of solution of acid is imitated when these artificial fibres are treated in the same manner. So that in this respect the behavior of the two fibres is identical. This fact may, on investigation, give some more definite explanation as to the cause of this phenomenon.

The brilliancy of the fibre in the coarse counts is greater than that of real silk. In the processes dealing with the production of these yarns directly from cellulose, the chief factor in obtaining this is the method of stretching the yarn during drying.

The nitrocellulose product, if properly denitrated, is very brilliant, owing to the surface condition of the fibres and as in other makes the continuous nature of the filaments.

Size of Individual Filaments.—The 120-denier thread of today varies in the number of the individual filaments, but it may be said not to exceed 25 in number; so that the size of the individual filament may be taken at from 5 to 8 denier. Actual silk averages 2.75 denier per filament. The fine denier Cellulo silk (30 to 50 denier) may contain 45 to 60 filaments, so that there the size is about 0.5 to 1.1 denier. The fineness of real silk has been exceeded in this case. In the sample produced of a 15 denier artificial silk thread (Yarmouth make), the individual filaments are 0.33 denier, or roughly 1/8 of the size of these of real silk. This is the first time that such a thread has been exhibited.

WORLD'S OUTPUT OF ARTIFICIAL SILK.

This has been recently given at about 3,000,000 kilos per annum at the present rate of production, against 1,700,000 kilos in 1906, and 600,000 kilos in 1896. These figures indicate an increase of 500 per cent in 13 years.

The nitrocellulose product still heads the list with

an output of between 1,300,000 and 1,600,000 kilos. The "copper-ammonia" process accounts for 1,100,000 to 1,300,000 kilos. The production of Viscose silk now amounts to 500,000 kilos.

These figures are large, but that will be greatly exceeded in the future. Within three years the viscose production may be doubled, as it is the intention to establish large works in America and elsewhere.

Output of Natural Silk.—The total returns for 1908 of the 24 European conditioning houses amounted to 51,445,000 lbs. These figures show an increase of 30 per cent in a decade (the average for the years 1896-8 being 34,929,400 lbs.), to which all the three great producing centers, viz., Europe, the Levant, and the Far East, have contributed. It is, however, significant that the increase in Europe is only 20 per cent against 50 per cent for the Far East, and 100 per cent for Asia Minor. This last increase is said to be entirely due to the efforts of the Silk Institute at Broussa; and the consequent introduction of scientific methods. In France the production of cocoons has not increased during the last years, in spite of large sums paid in state bounties, amounting to over £150,000 a year.

In 1906, 227 spinning mills spun 1,732,018 lbs. of silk in France. A comparison of these figures with those of the present production of artificial silk which has also been given elsewhere at 5,000 tons per annum, is instructive.

There is no indication that the large production of artificial silk is materially affecting the gradual and increasing production of the real article; especially as the present production is practically confined to high denier sizes (100 and above).

These have a use which may be stated generally to be specific to the artificial product. Exactly what influence the finer counts will have on the production of the real product is a matter which must be left to the future.

It is obvious that an enormous industry must spring up before any appreciable result is noticed in the direction of a restricted output of real silk. One can only speculate on the effect of such a revolution, if the finer artificial silk is manufactured down to 15 denier, and ultimately equals in strength the natural product. A rough opinion may be formed as to the future of the industry of the statement made in a report by the United States Consul at Lyons that already 30,000 hands are employed in this industry. If this figure is correct—and it may not be very far from the mark—this industry will in the future give employment to a great number of hands, and become an increasingly important branch of the textile industry.

It is interesting in passing to examine the position taken up by some authorities in this country, that there is an advantage in letting other nations work out new processes, and then establishing a position on the market with their early experience, and failures before us. The manufacture of this material under the conditions reviewed starts here with a financial handicap, for the leading Continental firms have already written down their works, plant, and rights, to a nominal amount, out of the abnormal profits in the past; they have a trained staff and great experience at their disposal. So that this must be set against any security arising out of such an assured position. On the other hand, it is claimed that in the two processes working today in this country, at Conventry and Yarmouth, respectively, the details of manufacture have been more successfully worked out here than on the Continent. The Viscose process is working on a large scale at Coventry, and there are indications that the Yarmouth research works may lead to an equally important development in the production and marketing of finer counts. The Flint works is not yet producing yarn.

RELATIVE VALUE OF DIFFERENT MAKES TO ONE ANOTHER AND TO SILK.

However interesting many of the products may be, from the scientific standpoint, after all their commercial value and adaptability is of first importance. It is too early to attempt to define their relative value either from the point of view of cost, or their respective physical or chemical properties.

I would suggest, with all reserve, that up to the present time this so-called artificial silk has hardly come into direct competition with the natural product; and that this has been an important factor in favor of its development in the past. It has created and is creating uses for itself. Its selling price bears little relation in its fluctuations to that of real silk; but with the demand in excess of the supply this is not in itself conclusive evidence in this direction, but it tends to confirm other known facts.

With the material now being introduced in finer counts, it may certainly enter into direct competition with silk. The substitute must then chiefly claim advantage on the grounds of price value. With an improvement in strength in both the dry and wet state, competition must increase, as it has done in the past between the natural and artificial indigo, and alizarin products, and be governed by the relative conditions of supply. The last 15 years have seen a marked improvement in strength and so-called elasticity. There is no evidence that the limit has been reached, or even approached.

There is also the question of the relative "covering power" of the yarns when woven. The ordinary makes of artificial silk have only 60 per cent of the covering power of natural silk. With an increase in the number of filaments in each thread a corresponding improvement in this respect naturally follows, as in the cellulo silk product. The limit today may be put at 60 to 75 per cent of that of real silk. So that there is still room for improvement in this direction. The density of the cellulose substance is about 10 per cent in excess of silk, so that a covering power of 90 per cent may be regarded as the maximum under equal conditions.

This is hardly the occasion to do more than point out the financial gain which has ultimately come to those who have carried this industry to its present state on the Continent.

Notices which occur in the textile journals from time to time indicate this in detail. The leading companies have paid steady and increasing dividends up to 50 per cent, or more (see Dreaper, J. Soc. Dyers and Col., 1907, p. 5, and Dreaper and Davis, ibid. 1908, p. 294).

The manufacture of yarns by a process entailing the solution of the raw material as a preliminary step has, therefore, become a reality. It is evident that the future will see an extension of output, due to the growing appreciation of the value of these yarns, and the consequent extension of its uses.

DISCUSSION.

The Chairman said, as Mr. Dreaper had referred to certain matters being kept secret, he wished to emphasise that it was not intended to induce specialists to reveal their secrets in these general papers. These papers were rather to be of a general character. Although they would appeal in the first instance to specialists, and would also interest those grown up in other industries, these general papers were chiefly meant for the benefit of the younger members who wished to gain wide technological information. He would leave the discussion of specific points of this industry to those mainly interested in it, and therefore best qualified to speak; but he hoped there would be some general questions asked by those who were not actually engaged in the artificial silk industry.

As Mr. Dreaper had mentioned the 1889 Exhibition and incidentally also quartz fibers, he vividly recalled the Chardonnet spinning-machine stowed away in a side alley of the Machinery Hall, and working without any attention; he was able to bring some of the fibres back with him to show to Professor Boys, who had at that time been producing quartz fibres, and was naturally interested in obtaining of the thinnest possible fibres for his modification of the Cavendish experiment. With regard to the question of the recovery of the solvents, which was only shortly referred to, could the author give any information as to the method of recovering the alcohol and ether by cooling to very low temperatures? Was it merely an idea that had been patented, or was it an actual process? He would like to mention Chardonnet's German patent 207,554; therein the absorption of vapors by means of sulphuric acid or by fats and oil was rejected, and substituted by absorption in aliphatic alcohols or their neutral esters.

Concerning the action of zinc chloride on cellulose, they knew that zinc chloride acted as a condensing agent on oils and fats, but very little was known of the rationale of the reaction. He should like to know how the process was controlled so as not to lead to the throwing down, as in the case of cellulose, of a horn-like or parchment-like product.

Mr. Henry Bronnert said the artificial silk industry had developed year by year in special ways which nobody had anticipated. At first, everybody thought that artificial silk would compete with natural silk, but it very soon proved to be an article quite by itself, and adapted also to entirely new articles which, in a great measure, it was the means of creating, e. g., for ladies' wear, for trimmings, for ladies' hats, etc., all industries in which silk had not previously been used. There were now quite a number of new industries using this yarn, and the new factories which were being opened would be sure to find a good demand for their products. There were, without doubt, still further new fields in which artificial silk could be used to advantage.

Mr. E. F. Cross considered that the paper was an opportune expose of the present position and progress of this remarkable industry. It was not the case that there was only so much business to go round, and a new factor appearing displaced so much of the old product. In the case of artificial silk, new classes of textiles had been introduced: the market showed that consumption was far from the limit, and he could increase Mr. Dreaper's total figures as stated, viz., 3,000 tons, to 5,000 tons per annum: and further, the demand was so far in excess of the supply that most factories were "sold forward" several months.

The Turkish Chamber of Deputies has been considering granting a concession for working the phosphate lands in Syria. The phosphate deposits must, in order to be exploited, be connected by a branch line of 25 miles with Amam, on the Hedjaz line, while at the same time a harbor must be constructed at Caiffa. The cost of these works is estimated at $2,500,000, which the concessionaires undertake to advance to the Government at 3½ per cent interest. The loan is repayable in 40 years, which is the duration of the concession. The concession holders will pay the Government $2.20 on each ton of mineral transported, and undertake to transport annually at least 100,000 tons. This will bring in $220,000 annually to the Government, out of which, after deducting the sum necessary for the payment of the interest and the redemption of the loan, the latter will have a surplus. The concessionaires will also have to pay proportional taxes in accordance with the mining regulations, and they undertake to supply the native farmers with all the superphosphate they require at cost price. The building of the harbor will entail the reclamation of 500,000 sq. yd. of land, half of which will be used for the erection of the necessary buildings, the other half belonging to the Government. On the expiration of the concession the deposits, the railway line, and the harbor will become the property of the State.

During the first five months of 1910 the imports of coal into France totaled 5,966,443 tons, of which 3,482,859 tons were from Great Britain and 1,563,567 tons from Belgium.

THE PLANT.

AVAILIBILITY OF UNDERGROUND WATERS FOR MANUFACTURING PURPOSES; METHODS OF SECURING SUCH WATERS WITH SOME COSTS.*

Other conditions remaining approximately equal, no large manufacturing concern can compete successfully with others of its kind, unless a large amount of good water is available at a reasonable price. If located on a large river or lake where soft water can be pumped under low head to all parts of the plant, water conditions may become ideal, the expense remaining at its minimum.

Manufacturing districts are constantly increasing and demanding larger quantities of surface water. City supplies have to be resorted to in a greater degree than formerly and the annual expense for water may amount to several thousand dollars. Confronted by such conditions, the mill operator often decides to look for an underground supply. It is our purpose to furnish certain preliminary data that may have been and may be used in such connection.

Underground waters are usually harder than those found on the surface. This has always been to their disadvantage for boiler use and generally for technical use as well. However, many wells driven in granite and related rocks afford very soft water. Aside from the disadvantage of hardness, well waters usually possess many advantages. They are free from mud and suspended vegetable matter and are usually uniform in quality and are safer for drinking purposes. For moderate depths, well waters are cooler than surface waters on the average throughout the year, and of still greater importance, their temperature is remarkably uniform. The annual cost of pumping from a good well is low, especially with a large boiler plant.

Water from expensive wells may be useless for any purpose. Calcium, magnesium, sodium and iron salts and hydrogen sulphide are all disadvantageous to the manufacturer. If heavily charged minerally the well is usually discarded.

It is not always necessary to drill a very deep well to get a considerable quantity of water. Many manufacturing concerns with which we are acquainted are getting ample supply of very good water from depths varying between 60 and 500 ft. It has been our experience that wells of less depth than the minimum mentioned are liable to surface contamination. In any event, the preparation in connection with drilling a deep well should include a report by a competent economic geologist who must be familiar with existing strata as they are usually found in the locality and must acquaint himself with well records or other information that will be useful in connection with the proposed enterprise. The drilling of a well must be taken up with a thorough understanding that the matter is a business venture with a possible total loss of capital employed.

If a favorable report from the disinterested man is made the question of the kind of well to be drilled, its location on the property and related preliminary matter must be taken up with a practical well drilling concern.

Four general types of well drilling are as follows: (1) Bit; (2) diamond drill; (3) steel shot; (4) jet.

The anticipated strata will in large measure fix the type to be selected. This is largely a matter to be left with the well driller. It should be remembered that the larger the diameter the greater the reservoir for water in case of emergency.

Having begun drilling operations, a contract should be made with a competent chemist who should test the water found both in reference to quality and quantity, while a record should be made of the exact depth under the surface at which the vein occurs. It is of great scientific advantage to retain a record of any well. This can be done by the chemist or by the geologist if samples of the broken rock or other material are saved in small bottles.

If the water in quantity or quality is found to be insufficient the casing should be driven by these points and other sources looked for at a greater depth in a new drill hole in other parts of the property. When a sufficient supply has been obtained this should be analyzed from a chemical and sanitary standpoint. In the meantime the driller should not remove his tools. If the quality of the water is sufficient for use its quantity must then be ascertained. If near the surface or containing sand, a centrifugal pump may be employed, while if the distance to the water is considerable an air lift may be used temporarily at least. Should the water be found either insufficient or of bad quality, the casing should be driven by this point and further investigations made.

Underground water formerly considered useless for boiler purposes is now successfully treated chemically. If a public supply costs 7 cts. per 1,000 gals., moderately hard well water can be treated and furnished less expensively, including depreciation of plant.

*A paper by W. M. Booth, Syracuse, N. Y., read before the Semi-Annual Meeting of the American Institute of Chemical Engineers, Niagara Falls, Ont., June, 1910.

While the quality of surface water may vary from hour to hour, underground waters are usually very constant and are thus ideal for softening processes. With the same chemical supply for months and with large variations in the quanitiy of water used from a well 130 ft. deep at Canajoharia, N. Y., the softened water has contained the following amount of calcium and magnesium oxides:

	Parts per Million.			
	Sept., 10, '09.	Sept., 30, '09.	Oct., 10, '09.	May, 25, '10.
Raw.				
CaO 141.....	13	17.4	19	10.4
MgO 27.....	17	9.4	16	14.5

The cost of softening this water is 1.2 cts. per 1,000 gals. We present the analysis of a very hard water applied to domestic use.

	Grains per gal.
Calcium carbonates	12.86
Carbonate of magnesium.....	.00
Calcium sulphate	96.90
Magnesium sulphate	38.60

The cost of softening this water is 19 cts. per 1,000 gallons.

Water containing above 10 grains of lime and magnesium carbonates and 40 grains of gypsum is about the limit for the lime soda softening process when the water is used in boilers.

Cost of Drilling.—In this particular we have the following from a prominent well drilling concern:

Replying to your favor of the 18th inst., we would say that so much depends upon local conditions that it is impossible to make estimates offhand that will be more than approximate cost of drilling wells. The character of the formation, the size and depth of the hole, skill of operators, cost of labor and fuel, etc., all enter into the problem. Current contract prices for this work vary from 75 cents to $20.00 per foot. A fair average for shallow wells (up to say 400 feet deep), including casing when needed, would perhaps be about $1.50 per foot for a hole not exceeding 6 ins. in diameter. Up to say 2,000 feet deep and an 8-in. hole the cost would probably run from $2.00 to $5.00 per foot. Above 2,000 feet from $5.00 up. These prices contemplate average conditions. When exceptionally hard rock or deep pockets of quicksand are to be entered, the expense would be increased and the rapidity of the work would be decreased. As an illustration of the effect of varying conditions, we have records of 6 inches per hour in hard granite and 20 feet per hour in soft formations made by the same machine, and both considered satisfactory progress under the conditions confronted.

Power Required.—To pump 1,000,000 gallons of water 50 vertical feet during 10 hours requires a theoretical consumption of 2.25 HP.; pumped by steam this is increased to about 6.3 HP. If power can be furnished at $50 per horsepower year of 312 days, the annual cost of raising this water will be $315, or about $1 per day.

THE EFFECT OF PRELIMINARY HEAT TREATMENT UPON CLAYS.*

By A. V. BLEININGER.*

This subject was brought to our attention by a practical problem which involved the use of a very plastic clay possessing a peculiar structure and known as joint clay. This material is glacial in its formation and while readily molded it cannot be dried economically owing to the great loss due to cracking. The cracks observed seem to indicate a somewhat cubical structure. These clays are exceedingly fine grained and the trouble experienced is evidently due to excessive plasticity. Long continued storing in the sun or weathering during winter seemed to overcome this difficulty. In our work the same result was obtained by drying the clay as it came from the bank before molding it, to a temperature of 200° C., when it seemed to lose its objectionable qualities, showed a greatly decreased drying shrinkage and gave but a small loss on drying the ware.

Owing to the lack of other clays the inability to work up this material has been a source of considerable loss to the brick manufacturers, especially since some of the joint clays burn to a very desirable color, show excellent strength and hold up well in the fire.

There is no practical objection to carrying out the preliminary drying in a rotary dryer since the cost of this process is not prohibitive in many instances, though, of course, it would be advisable wherever possible to make use of the natural weathering and freezing, either by winning the material in the fall and exposing it to the weather in heaps or by plowing trenches into the shallow clay deposit and thus permit of this action without digging.

Other industries, such as the manufacture of roofing tile, terra cotta, etc., might find it advantageous to use the rotary dryer in order to improve the working quality of highly plastic clays, reducing the drying shrinkage, warping and drying loss.

In this connection, however, we must understand clearly that clays deficient in plasticity are injured by this treatment since they lose part of the plastic character and binding power.

There are many clays which cause drying troubles owing to their excessively plastic, fine-grained structure in which the water has great difficulty in passing to the surface of the ware, so that the rate of evaporation on the outside is far in excess of the rate of flow from the interior. In many cases simple dilution with sand is sufficient to equalize the distribution of water; in others, this procedure fails, as in the case of the joint clay.

It may be, however, that by pugging the sand into the clay with extreme thoroughness the difficulty might be overcome in all cases. Usually, the preparation is far from being sufficient since these

*From the Transactions of the American Ceramic Society, Pittsburg, Pa.

clays coming from the bank in the wet condition are not readily worked by the machines generally employed and it would be necessary to resort to the use of the wet pan.

We have no reason for assuming that the preliminary drying treatment brings about a permanent destruction of part of the plasticity, and there is little doubt but that such a dried clay when exposed to the weather in the moist state would again resume its original plastic character. This resumption, however, requires a certain amount of time which is not allowed it in the usual process of manufacture. Hence, by making use of this lag we obtain the benefit of reduced plasticity. We should expect clays to differ in this respect. Some of them undoubtedly show considerable lag and hence preliminary drying could be used to advantage, while others would exhibit such a short lag that they would resume their full plasticity in the ordinary course of preparation and drying.

As to the actual change brought about by the preliminary drying we must have recourse to analogous cases. If clays are colloidal, as we have every reason to believe, they ought to follow the behavior of colloids in a general way. Fortunately, some work along this line has been carried on with pure colloids such as aluminum hydroxide, ferric hydroxide, and silicic acid. For instance, it is a well-known fact in the laboratory that such gelatinous precipitates as aluminum hydroxide when dried on the filter are much easier to wash free from salts than in the wet condition. A pottery body after being made up into ware and dried in the usual steam dryer and again made plastic is found to be somewhat deficient in working quality and hence such waste is used for casting.

J. M. Van Bemmelen in dealing with pure silicic acid assumes this substance to possess a structure which represents a more or less advanced transition stage between a solid and a liquid and hence encloses a certain amount of liquid. The colloid does not form a chemical compound with the liquid but the case is one of absorption. The liquid between the pores of this cellular structure leaves at first at a rate corresponding to the decrease in the content of absorbed liquid. At the same time constant changes occur in the physical condition of the substance which are slow at ordinary but accelerated at higher temperatures.

Van Bemmelen studied the inversion points by placing the silicic acid gels into dessicators containing 36 concentrations of sulphuric acid and hence corresponding to 36 aqueous tensions. He found several inversion points in the resulting dehydration curve. First, the substance becomes dull and fluorescent, then white like porcelain and finally opaque white, like chalk without gloss. This inversion changes the dehydration curve, since for a distance it runs parallel to the abscissa. The capacity to hold water then decreases more rapidly than before the inversion point. On continuing the dehydration still further the dimness disappears just as it appeared. The gel becomes porcelain-like, of bluish fluorescence, and finally as clear as glass, remaining thus until the final dehydration. Also, when the gel is at once exposed to higher aqueous tensions, after the inversion the gel becomes gradually homogeneous and clear as glass. These inversions may be repeated and they are hence reversible under certain conditions. It is evident, therefore, that certain changes occur in the micellian structure of the colloid at these inversion points, forming new coagulations which disturb the continuity of the dehydration curve.

By taking now the silicic acid pats which had been carried on to the lowest aqueous tension (most concentrated sulphuric acid) and placing them in the dessicators containing the more dilute sulphuric acid solutions, rehydration takes place.

Plotting again the molecules of water at each stage against the aqueous tension, it was found that the first dehydration curve was not reproduced but that a distance lag was observed corresponding to the hysteresis of the magnetization curve for iron. In other words, while a certain aqueous tension in the case of the fresh silicic acid corresponded to a certain amount of water, the same tension in the rehydrated substance was equivalent to a smaller amount of water.

We observe thus a strong similarity between the silicic acid, one of the best known colloids, and clay.

For the purpose of investigating the behavior of clays it was decided to select seven plastic clays of which two had given trouble in drying to such an extent that their use had to be practically abandoned by manufacturers. The other clays were taken because they simply represented types of plastic materials.

No. 1. Exceedingly plastic clay from Ft. Pierre, North Dakota. (Through the kindness of Prof. Orton.) This clay was exceedingly difficult to dry.

No. 2. Fire clay from St. Louis, Missouri.

No. 3. Tennessee ball clay No. 3.

No. 4. New Jersey sagger clay—J. Prall, Woodbridge, N. J.

No. 5. Pike No. 20, English ball clay.

No. 6. Texas Lone Star kaolin.

No. 7. Minnesota joint clay, Albert Lea, Minn. This clay is causing great loss in drying drain tiles and brick.

It is evident that the simplest and best method of following the behavior of these clays in drying is the determination of the volume shrinkage. Although in this work it is proposed to study the porosity of the clays thus treated, determined from the real and apparent specific gravities, the exterior volume changes must, in the nature of the case, remain the most important criteria of the behavior of the clays. Each of the seven clays was thus made up into a pat of about 400 grams, by adding sufficient water to convert it into a soft plastic mass and working it thoroughly. In order to reach a state of equilibrium and to

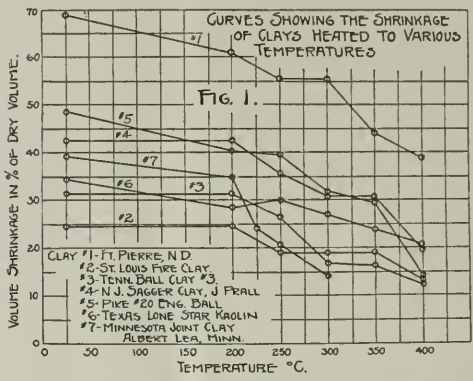
allow sufficient time for the development of plasticity, the seven pats were allowed to remain in a dessicator over water, for one week. Then after thoroughly working the clay by hand from each pat there were made six smaller pats weighing about 50-60 grams. One pat of each clay was made into a bricklet about 35 grams in weight, the volume of which was determined at once by soaking in petroleum for some time, then placing it into a Kjeldahl flask and measuring the volume of petroleum displaced by means of a burette reading easily to 0.05 cc. The experimental error in the measurement of the volume by many trials was not found to exceed 0.1 per cent. These seven bricklets (one from each clay) were then dried to constant weight in a water-jacketed copper drying oven at 85°-90° C. When dry they were immersed in melted paraffine for some time, which was allowed to drip off, and when cool they were placed in petroleum. After about an hour their volumes were determined as before. The amount of water necessary to make the clays into a plastic mass was gauged entirely by the judgment of the operator and this was found to be as accurate as any other possible means.

The remaining five pats of each clay were heated to five temperatures (one for each temperature) in a round, heavy drying oven, provided with an air jacket and with three tubulatures. A thermometer was inserted into the middle opening. The temperatures selected were 200, 250, 300, 350, and 400° C. After reaching the desired temperature the heat was held there for three hours. After this drying treatment the pats were crushed in a porcelain mortar, passed through a 20-mesh sieve and made up with water into bricklets of a soft consistency weighing about 35 grams. These were allowed to remain in a dessicator over water for 16 hours so as to allow time for the development of plasticity and yet not too long so as to bring out the lag in the volume change. After removing from the dessicator the volumes of the bricklets were determined as described above and they were placed in the water jacketed drying oven at 85°-90° C., where they remained until constant in weight when their volumes were again ascertained.

In Fig. 1 the volume shrinkages of the clays expressed in terms of dry volume have been plotted for the six temperatures and it observed that no significant changes occur until 200° C. is reached when all clays excepting No. 6 show a decided drop. The clays differ, however, as regards working quality after being heated to 200°. The Ft. Pierre clay has not yet lost its excessive plasticity at 200° and does not become granular in its appearance until 300 has been reached. At this temperature a distinct coagulation takes place and the clay appears to have changed in its entire physical behavior. It is molded far more easily and dries without difficulty as far as could be told from the small bricklets made. There was not sufficient clay at hand for making larger pieces.

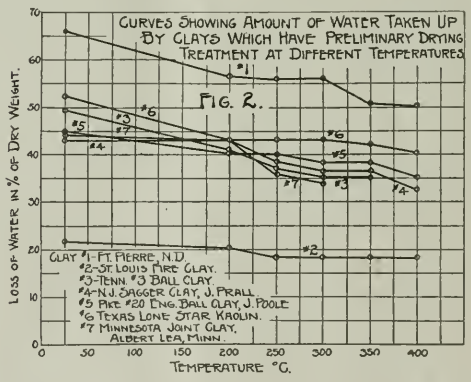
The St. Louis fire clay did not show a decided change in its properties below 250° and the total effect was less marked in this material than in others, since it did not possess excessive plasticity.

The Tennessee ball clay did not appear to be changed up to 300 , when it had lost a great deal of its plasticity and had become "granular" in appear-



ance. The same was practically true of the New Jersey sagger clay and the English ball clay, although the latter was more sensitive to heating at 200° and had suffered an appreciable loss in plasticity at that temperature.

The Texas kaolin was remarkably resistant to the heating treatment and did not show any decided



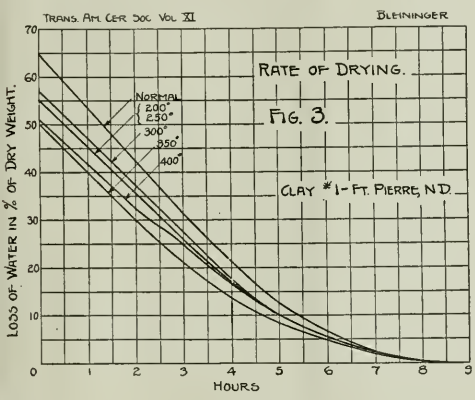
change in its plasticity till a temperature of 400 had been reached.

Particular sensitiveness to this treatment was shown by the Minnesota joint clay, which suffered a decided change in its character as was indicated by a change in color, the assumption of a granular appearance and decrease in plasticity at 200°-225°. In this condition it was dried without any difficulty and worked well in moulding.

In each case after heating, the amount of water required in making up these clays to a plastic mass was decreased considerably, as is shown by the curves of Fig. 2. However, no direct relation seems to exist

between the drop in the volume shrinkage and the amount of water required. This seems to indicate that we are dealing not merely with a decreased capacity for water but also with a change in the entire physical structure of the clays.

In order to determine the rate at which the drying takes place in the case of the different clays heated to the different temperatures, 36 small cylinders were made of six clays, corresponding to the five temperatures and the clays in their normal state. These were molded in the same mold and were placed into a water-jacketed drying oven kept at a constant temperature of 60° C. These cylinders were weighed every hour. The losses of water in per cent were then calculated and plotted as shown in Fig. 3. From these curves we observe that the rate of drying is not increased by the heating instrument and remains practically the same as for the normal clay. Taking into account the lower amounts of water in the dried clays the rate of loss is evidently the rate of evaporation under the constant conditions of the drying oven.



CONCLUSIONS.

1. The loss in plasticity suffered by clays at increasing temperatures is not abrupt but gradual. In the time allowed the clays examined in this work (16 hours) for the resumption of plasticity the original condition was only partially recovered, resulting in decreased shrinkage under practical conditions of working.

2. The decrease in shrinkage went hand in hand with a decrease in the amount of water required to make the clay into a plastic mass, but no simple mathematical relation existed between the two factors.

3. As the shrinkage decreased the clays became "shorter" and appeared to become granular. Some of the clays changed in color, appearing to become darker and reddish.

4. The rate of drying of the dried clays did not differ materially from the rate for the undried clays.

5. It does not follow that the more plastic a clay is originally the more it is affected by the heating treatment. (Texas clay.) Clays of lower plasticity may be rendered still less plastic but not at the same rate as highly plastic ones.

6. The temperatures at which these changes take place may vary from 200° to 350° C. for different clays, although the latter temperature is probably the limit for most clays as far as practical considerations are concerned. Further decrease in plasticity is not usually desirable. Each clay therefore seems to have its own practical inversion temperature.

7. If exposed to the action of water for longer periods it is very probable that the clays would resume their original plasticity. However, in the time usually allowed in working clays the slowness or the "lag" in the resumption of the plasticity may be used to good advantage in dealing with exceedingly plastic clays or in manufacturing such products as roofing, tiles, terra cotta, etc.

All of the clays tested to 250° and above caused no difficulty in drying and showed no cracking.

In carrying out this work the thanks of the writer are due to Mr. G. H. Brown of the U. S. Geological Survey for the care and attention given to the experiments and measurements involved in the investigation.

DISCUSSION.

Mr. Purdy: Those who have "rubber" clays will be interested in discussing this paper. I know W. D. Gates is interested in this subject.

Mr. Gates: I am very much interested, but absolutely as a learner. I was very much interested in the experiments described in this paper, for they seem to bear out some experiences of my own, some difficulties I had; but I do not think I can throw any light on the subject. I have found clays which would look exactly alike, one of which would dry without cracking and the other would be nothing but cracks. That is how they came to be called "rubber" clays. The only difference I could see was that one was possibly a little darker shade than the other. Then when the clays were mixed up in a thick slip a difference could be noticed in the fact that when gathered on the slab and swept up in pyramid form by the hand, the good clay would retain its position while the other would flow off in the manner of quicksand. The difficulty led to our having to give up the use of some clays. I am rather inclined to think that this heat treatment might have benefited the clays, and I intend to do some experimenting. This recalls to my mind an incident which goes to show how we work in the dark. For convenience in handling, we constructed a drier, the clay being brought in and thrown on hot steam pipes, so we did this same thing without intending to. I remember, since talking with the author of this paper, that we secured good drying results from these clays. I am very glad, indeed, that Professor Bleininger has undertaken this investigation.

Mr. Campbell: I would like to corroborate what Mr. Bleininger has said in regard to reducing cracking by this perliminary heat treatment. Last summer

I was testing out three clays and did this very thing. A clay that would crack without this preliminary heat treatment, I found would come out perfectly smooth, without cracks or fractures, if first given this treatment.

Mr. Kerr: In regard to the curve shown here, as I understand it, it is the actual volume shrinkage and not the apparent volume shrinkage?

Mr. Bleininger: The actual cubical shrinkage.

Mr. Purdy: The exterior cubical shrinkage?

Mr. Bleininger: Yes, sir; exterior, not the absolute.

Mr. Purdy: Have you made any observations of the clay particles themselves?

Mr. Bleininger: Not yet; the experiments were begun a little over three weeks ago. They are under way now, but of course we have not done many things we would like to have done.

Mr. Purdy: No doubt. The question is as to measurements of the clay particles themselves.

POINTS IN THE RELATIONSHIP OF THE PULP MILL TO THE PAPER MILL.*

By T. LINSEY CROSSLEY.

There are three characteristics of wood pulp that enter largely into the economics of the paper mill, namely, cleanliness, moisture contents, and bleaching qualities. There are other points of relationship affecting details of finish and beating, but in this paper it is proposed to consider the points above mentioned, which are sometimes different or co-related effects of the same causes, as, for instance, when fine dirt is present as a result of insufficient water in treatment for opening and washing; this affects its cleanliness, its bleaching economy, and indirectly its moisture content.

1. Cleanliness.—In cases where rossed pulp wood is transported by rail or steamer, the conditions attending loading and unloading deserve close attention. Some dirt from the vat of a news machine was found to contain a very large proportion of unburnt coal. In this works pulp wood was conveyed into the mill from the cars on the same conveyor as the steam coal.

Perhaps the most important point in the dirt problem is the wood room at the pulp mill. To prevent waste from excessive cutting in the barker, and at the same time prevent the introduction of rotten knots or gum seams to the chipper, requires intelligent consideration. A 10-in. block may be trimmed down to 8 in. in an attempt to take out a gum seam which should only be treated with an axe by hand. Too much reliance is placed on machine work in many mills. A good splitter and a few good men with axes will prove profitable in the wood room, and remove a cause of much heartache to the paper maker; for once the rotten knot is in the digester, a large proportion of its contents will surely find its way to the finished paper.

A pulp maker endeavors, of course, to turn out good qualities of fibre, but chips may get charred round the steam inlet over larger or smaller areas, or acid may not be properly distributed in the digestor, resulting in raw chips. Both these abnormal products are intimately mixed with the stock when the digestor is discharged and resort is had to various mechanical devices to try to eliminate them. The success of these devices depends in most cases on the proper appreciation of their capacity, limits and functions, i. e., a screen is a screen and not a conveyor. In many cases the capacity is overtaxed, resulting in wasteful tailings, which aparently affect only the pocket of the pulp man, but he does not by any means pay all the bill. He may screen these tailings and run the fines back to the stuff-chest as good, or he may put them through a grinder to mix with stock from his save-alls and get rid of a lot of it to the paper mill in the form of wet laps which will probably take 25 per cent or even 50 per cent more bleaching powder than his best quality. Various forms of riffles and flow boxes are used for the sedimentation of the heavier dirt, but often a pulp mill has not been designed in such a way as to allow a sufficient amount of water to thin the stock, and the dirt is carried along. The weight of the stock tends to force soft dirt through even the reliable flat screen, and much more through the various forms of centrifugal or revolving screens.

Pulp mills would often sort their stock to more uniform grades if adequate provision had been made for this in designing the mill, i. e., large and well arranged warehousing. A small machine for making wrapping would in many cases be not only profitable, but would remove the temptation to keep down the screenings pile at the expense of the No. 1 stock.

2. Moisture Contents.—There are several important considerations affecting this point, yet these may be traced to, and in large measure could be remedied at, one part of the pulp mill; that is, the stuff-chest in its relation to the wet end of the drying machine or the vat of the wet machine, if the product is in wet laps. The maximum variation of moisture in the wet lap is very much less than that in the dry pulp, and thus it is a simpler matter to take an average sample. Dry pulp may vary more than 30 per cent as running on the machine, and if everything is not in first-class order, there may be a variation of from 3 to 8 or even 10 per cent between the moisture test at one side of the sheet and that on the other. It is this great variation that makes adequate sampling difficult. It arises from several causes, e. g., insufficient steam in the dryers, not as many dryers as there should be, the desire of the machine tender to put out a heavy run, and other minor causes; but the trouble may often be traced to the fact that the stuff-chest is not large enough to maintain a reserve, resulting in the production of alternate thick and thin sheets, incidentally

*Paper presented before the Canadian Section of Society of Chemical Industry and reprinted in the Journal of the Society.

bringing with the thin sheet much of the accumulated dirt at the bottom of the chest. This variation in the sheet renders inaccurate any system of testing which relies on equal area of strips or sheets. A test for this class of pulp must take account of bulk, but here another difficulty presents itself; many pulp mills do not put up their product in packages of equal weight. This is not a difficult thing to do, and it would materially assist in correct sampling, permitting the taking of a test sample from some stated weight, say every 1,000 lbs.

3. Bleaching qualities.—Given a fairly well cooked sulphite pulp, its bleaching quality depends, in a very large measure, upon its treatment between the digestor and the drying machine, and in some measure, upon its passage over the drying machine.

From observation of the bleaching of sulphite pulp received as wet laps and that received in the machine dried form, both of nearly equal paper making quality, it seems probable that some of the bleach-consuming impurities in the stock were eliminated either by oxidation or evaporation upon their passage over the drying machine. The pulp received as wet laps when first received, required from 15 per cent to 18 per cent of its weight of bleach, though as result of better treatment noted below, the consumption of bleach was reduced from 12 per cent to 15 per cent, whereas the pulp received as dry seldom required more than 12 per cent and should, with a more modern arrangement or a little more time, not require more than 10 per cent of its bone dry weight for good book bleaching.

It is an open question whether the quick cook blow-off system as used at present does not produce a pulp which is expensive to bleach; with slower cook and the dumping system, a more economically bleaching pulp is produced. It is quite possible for a sulphite mill to cook pulp for one or the other of two main classifications, not merely cooking all the pulp they can handle, and selling for all purposes irrespective of quality. These two main divisions might be: (a) Slowly cooked, dumped and well-washed pulp to be bleached for "book," "magazine" and "writing." (b) Quickly cooked, blow off pulp for news, manilla, etc.

The effect of more generous use of water in washing pulp was shown in a make of pulp in wet form which, during a period of low water, was taking an equivalent of about 18 per cent of its weight (bone dry) of 36 per cent powder, but later, after more careful washing, was bleached in less time with about 15 per cent of its dry weight of powder. As a result of a series of experiments it was concluded that a more economical pulp for bleaching may be produced by a hot-cold-hot series of washings, running off over a drying machine to finish at about 90 per cent—95 per cent air-dry. Pulp over 95 per cent air-dry does not disintegrate quickly in the bleaching tubs and the bleach does not penetrate so well as with pulp containing a little more moisture. The washings referred to do not as a rule require any more plant than pulp mills are usually provided with, saving, in some cases, a more adequate water supply. The first hot wash can be given by running water in with the stock when a digestor is being discharged; the heat of the pulp from the digestor being sufficient to bring the whole mass up to a sufficiently high temperature to wash out much of the resinous liquor remaining in the pulp after draining in the digestor. The size man and the beater man are often in this matter the scapegoats of the pulp maker, for many of the resinous spots found in the finished sheet may be easily traced to the sulphite mill. The pulp now in the blow pits can be drained and washed once more with cold water, or may be taken after the first hot wash into the system, relying on the flow box, strainers, and screens for the subsequent cold washing. In most mills there are arrangements for thickening the stock before it goes to the machine chests. In cases where this is not so, such machinery would have to be installed, as the stock flowing to the machine should be fairly uniform in fibre content. The final hot washing is to be done at the wet end of the machine by means of a continuous sheet of hot water running on the pulp before it comes to the suction boxes. This arrangement not only improves the bleaching qualities of the pulp but materially aids in the elimination of moisture at the suction boxes by reducing the internal friction. It is sometimes difficult to secure the flow of hot water on the felt in a continuous sheet without breaking the pulp sheet, but it can be done and will pay both in freight and bleaching quality.

With the above considerations in mind, more valuable pulp for paper making may be produced, and friction between the pulp mill and the paper mill be avoided, by attention to the following points:

1. More careful culling of wood blocks.

2. Provision for hot washing at time of dumping and ample water supply for sedimentation of dirt. As a basis for water in the flow boxes and riffles, a suply of water should be provided that will reduce the fibre contents at these points to 0.5 per cent.

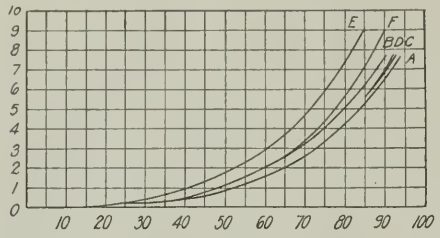
3. Stuff-chest reserve sufficient to maintain average sheet on drying machines for at least one hour and a half.

4. Proper and uniform steam provision for dryers on machine; a sufficient number of dryers to dry sheet without overheating; regulation of stock at wet end of machine and provision for hot water treatment at this point.

5. Sampling of individual packages on loading in preference to sampling at machine. Bales or packages to be made as nearly as possible of equal weights to permit of samples being of uniform bulk for same weight of pulp.

Treatment on the above lines would produce a pulp that would require, on the average, about 10 per cent of its bone dry weight of 36 per cent powder for

bleaching instead of the 12 per cent to 20 per cent limits now expected.



EXPLANATION OF DIAGRAM.

Stock used, wet laps, vacuum system with blow pits.

Bleach strength equivalent to 13 per cent of 36 per cent powder calculated to air-dry stock.

Amount of bleach, water and stock were the same in all cases.

A—Pulp as received.

B—Pulp after washing in cold water.

C—Pulp after washing in boiling water.

D—Pulp washed in water at 110° F.

E—Pulp washed over night in cold water, squeezing and soaking over night at 212° F.

F—Pulp after being dried bone dry in oven at 212° F. for 15 hours. B, C, D and E were best color and about equal.

It will be noted by referring to "C" and "D" curves that there was no economy attained by the much higher temperature of "C" as compared to "D." "E" of course represents an extreme case. Maximum color was attained about the seventh hour and with a variation of about one-sixth of the bleach between the two extreme cases.

PROTAL: A NEW PRODUCT FOR USE IN THE ARTS.*

By Dr. F. G. WIECHMANN.

The base of this new material is vegetable-albumin, under which generic term vegetable ivory, the vegetable caseins, glutens, hemi-celluloses, reserve celluloses, horny-albumins, etc., are included.

The vegetable-albumin, from whatever source derived, is treated with one or more substances, which convert it into a new substance, a plastic eminently well adapted for use in the arts and industries. To this new plastic the name Protal has been given.

Any and all materials commonly used in the rubber industry may be incorporated with Protal. About one hundred different Protal compounds have been produced and, of course, the properties of these compounds vary with the ingredients employed.

Protal can be molded, pressed or otherwise formed into any desired shape. It is odorless, resilient, and can be cut, sawed, filed, polished, tapped and countersunk, like hard rubber. It can be colored by dyes, and all pigments can be incoroprated with it. It is non-explosive and is very resistant to the influence of heat and electricity.

Among the great number of Protal compounds which have been made, there are some which contain rubber, rubber substitutes, shellac, rosins, asbestos, etc. Some of these products remain plastic and moldable for a long time and possess the remarkable quality of hardening on immersion in water.

Compounds of Protal with rubber, rubber fluxes and some of the so-called rubber substitutes, exhibit a wide range in their properties. They can be made hard, semi-hard or soft, which of these qualities they are to exhibit being determined by the choice of loading materials and by the conditions of heat and pressure governing their production.

Among the most important compounds of Protal is Protal-Bakelite, Bakelite being that most interesting and valuable product, the discovery of which was announced last year by Dr. L. H. Baekeland of Yonkers, N. Y., and which is, as is well known, a condensation product of phenol and formaldehyde.

Protal-Bakelite possesses many valuable qualities. It exhibits great resistance to nearly all chemical solvents. It is an excellent electric insulator, is capable of taking a high degree of polish, can be produced in almost every color, and is well adapted to the many purposes and uses for which hard rubber and hard rubber compounds are, at present, almost exclusively employed.

It possesses the great advantage over hard rubber of not being subject to oxidation, of not softening on the application of heat and of not being attacked by oils and bodies of a similar nature.

Any and all materials, organic as well as inorganic, may be incorporated with Protal-Bakelite, thus giving rise to a great number of compounds which possess very different qualities and properties and which are adapted to a great variety of uses.

It would be practically impossible to specify all of the uses to which this new plastic may be put. It need only be borne in mind that this is a plastic which can be fashioned into any shape, which can be molded and pressed, which is capable of taking a high polish, which is not affected by water—cold or boiling—which is resistant to practically all chemical solvents, which can be tooled and machined with ease and which is produced in both flexible and rigid form.

In cost, this material compares very favorably with rubber and every day witnesses its introduction into new fields of industry.

The manufacture of Protal and of Protal-Bakelite is in the hands of a New York concern, Protal Co., the works being located at Bridgeport, Conn., and at Yonkers, N. Y.

*Paper read at the Semi-Annual Meeting of the American Institute of Chemical Engineers, Niagara Falls, Can., June 22d to 24th, 1910.

THE LABORATORY.

THE SAMPLING OF CONCENTRATED AMMONIACAL LIQUOR.

By W. C. KLOTZ.

The correct sampling of concentrated ammoniacal liquor in large tanks or cars, is not as simple a matter as it may seem at first glance. Very frequently, through ignorance of conditions, or negligence, samples are taken that do not at all represent the correct ammonia content, causing a lot of needless trouble, which could easily be avoided by an accurate manner of sampling, and a clear perception of conditions at the time of sampling.

A method, often adopted, is that of sinking a weighted, and corked bottle about half way down into the liquor, jerking out the cork by means of a long string, allowing the bottle to fill, and then using this as an average sample. The fallacy of such a method lies in the fact that the contents of a tank are not necessarily homogeneous. On top of the liquor is probably floating more or less light liquor oil; at the bottom will be found tarry sediment; but in the center where the sample is taken, will be clear liquor. If now the ammonia content of such a tank be calculated from the weight, or measurement of the contents, using the analysis of a sample taken as above, the entire amount, liquor, oil and sediment will be taken as liquor, giving a total ammonia value in excess of that actually present. In cold weather an additional stumbling block is to be faced. In all probability crystals will form, the liquor being saturated at that temperature, and will settle to the bottom. If for any reason such as an increase in outside temperature, the liquor becomes warmer, some of these crystals will redissolve, but the resulting strong solution, on account of its greater specific gravity, will remain at or near the bottom. Hence we have two unequal layers of liquor of different strengths, an accurate sample of which it is impossible to obtain by the above means.

In an effort to eliminate such errors, tanks are often sampled by taking a bottleful each from the top and bottom, or top, middle, and bottom of the tank, and the outcome of this way is the adoption of the "sampling pipette," (Fig. 1). At the end of a long hollow stem is a chamber capable of holding about one pint, and supplied with a valve at the bottom, which is opened and closed at will by means of a long rod running through the stem. With this apparatus samples may quickly be taken at any depth in a tank, and in as large a number as desired.

But while a fairly satisfactory average sample may thus be obtained of the liquor contents of a vertical tank by uniting a number of samples taken at different depths, this is not always so in the case of a round, horizontal one. If such a tank, say 72" in diameter, 25 feet long, and about 7/8 full, is sampled at different depths, for every pipetteful taken out at A (Fig. 2), 75 gallons of liquor per length of tank are represented, at B, 100 gallons, while at C only about 60 gallons. The liquor at C is however, not necessarily the same strength nor quality as at A or B, for if crystals are present it will be stronger, while if the pipette, on

Fig. 1.

going too close to the bottom, stirs up the sediment lying there, it will, on being filled contain besides liquor, a goodly amount of black dirt. On uniting all these pipettefuls, to make an average sample, the samples A, B and C, being all equal in quantity, will of course apparently represent equal cross sections, while as a matter of fact, if A represent 75, B will represent 100, and C only 60 gallons. Furthermore, when sediment is present in the bottom sample, the apparent amount of dirt in the liquor, as shown in the resulting average, will be out of all proportion to that really existing therein. Needless to say, such an "average" will not represent the true facts.

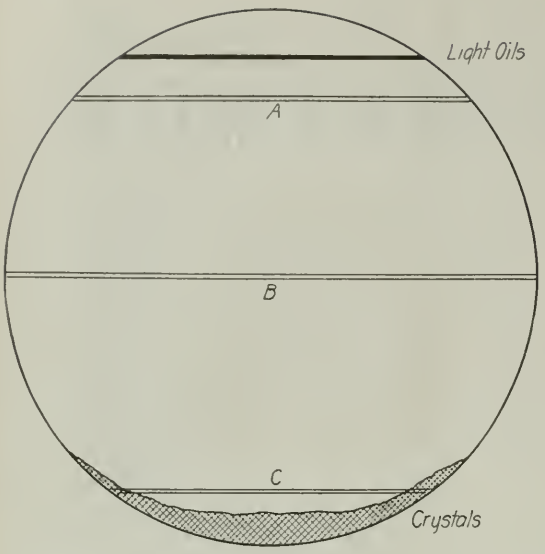


Fig. 2.

These drawbacks apply principally to the sampling of tank cars, in which are constantly encountered all sorts of conditions of oil on top, sediment, and in cold weather, very frequently layers of crystals, at the bottom. The only reliable method of car sampling is the so-called "drip sample." Briefly, this is a sample obtained by continuously bypassing a fraction of the liquor as it runs into or out of a car, so that when the transference has been made, there is at hand an exact duplicate of this liquor in strength, quality, and proportional amount of ingredients. The apparatus is as follows: A one-gallon bottle is provided with a 2-hole rubber stopper, through one hole of which extends a long glass tube, A (Fig. 3), extending to the bottom, and through the other a short one, B, bent at right angles, and passing just through the stopper. To the top of tube A is attached a device C to enable one to see and regulate the quantity of liquor flowing in. A little mineral oil is run into the bottle to prevent possible surface loss of ammonia, and C is then connected to the pump or pipe carrying the liquor into or out of the tank, and the flow so regulated that the time required to empty or fill the tank, is just sufficient to fill the bottle. Such a sample will represent the exact condition of the liquor, and in the same proportion in which it exists in the tank. To be sure that no ammonia has escaped through the oil, a double trap D may be placed at the outlet tube B, and the water in the trap tested when the sampling is complete. It is probably unnecessary to state that the liquor in the bottle must always be kept cool, and in warm weather should be placed in a vessel containing cold water.

As will be noted, no account is taken of crystals that may lie at the bottom. To determine these, they are, after as much as possible of the liquor has been taken off, dissolved in warm (not hot) water using a scraper to assist solution if necessary, the resulting solution weighed, a sample taken as above, and analyzed as in the case of the liquor.

A MAGNETIC HOLDER FOR THE MICROSCOPICAL EXAMINATION OF METALS.*

By ALBERT SAUVEUR †

In order to examine a piece of metal under the microscope it is necessary, of course, that the polished and otherwise prepared surface be held in a plane accurately perpendicular to the optical axis of the instrument. This may be accomplished by shaping the sample so that it will have two sides exactly parallel and preparing one of them for examination. The operation, however, is at best tedious and laborious and metallographists have endeavored to replace it by the use of more or less ingenious devices for holding the specimens in the proper position. Some embed their samples in wax or in other plastic material, while others have recourse to stages provided with special leveling devices. These schemes have been fully described and it is unnecessary to recall here their un-

*Iron Age, June 23, 1910.

†Professor of Metallurgy in Harvard University, Cambridge, Mass.

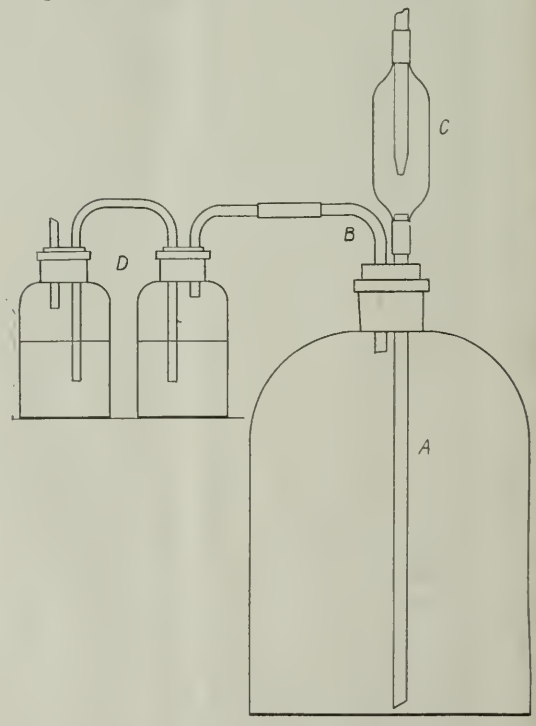


Fig. 3.

satisfactory character. The simple little holder which I designed in 1892 (Fig. 1) gave much greater satisfaction and is, I think, very widely used in this country. The specimen is held firm in place by a rubber band and the holder placed on the stage like an ordinary microscopical slide. If the correction of the objective demands it a cover glass may be inserted between the sample and the holder. It will be apparent that the required manipulations are very simple and quickly performed.

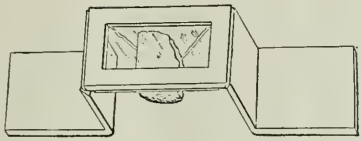


Fig. 1—Specimen Holder, Designed in 1892.

It occurred to me recently that a still simpler and more effective device could be used to hold in place samples of iron and steel and other magnetic substances. The results obtained were highly satisfactory and I am confident that the value of this little holder will be fully appreciated by those who apply the microscope to the examination of iron and steel samples. The device consists of a V-shaped permanent magnet of special steel about 1 in. wide and 2½ in. long (Fig. 2). The little magnet is placed on the stage of the microscope like an ordinary glass slide (Figs. 3 and 4) and the sample to be examined suspended to it from below, being held in place by the attraction of both poles. Small samples are suspended near the small end of the V opening, while larger ones are placed

Fig. 2—Magnetic Specimen Holder.

nearer the wide opening. This little holder, therefore, is universal in its application within the limits of samples of suitable size for microscopical examination. If the opening of the stage be sufficiently large, say 1¼ in. in diameter or more, the magnet may be kept permanently on the stage, as the samples may then be readily removed or attached to the magnet with the fingers from below the stage. This adds so much to the convenience of the device that it is strongly urged in case the central aperture of the stage is too small to have it suitably enlarged. The magnet is kept in place like any glass slide by the clips of the microscope, and as with ordinary slides may be moved about for the inspection of the different parts of the preparation. The side of the magnet resting on the stage having been ground perfectly flat, it will be evident that the surface of the sample under examination will always be accurately in the proper position, permitting the use of high-power objectives without fear of difficulty arising from an ever so slight inclination of the sample.

When used in connection with a mechanical stage (Fig. 4) the convenience of this holder becomes more

Fig. 3—Plain Stage Magnetic Holder and Specimen.

apparent still and its usefulness is further increased. It then affords, moreover, a ready means for the repeated examination of the same spot of any sample at any time. In such use the holder is laid upon the prepared surface and two scratches made by drawing a needle across the specimen along the sides of the V opening, as shown in Fig. 2. When it is desired to examine the sample the latter is suspended to the magnet so that the needle markings correspond closely with the sides of the magnet opening, in this way se-

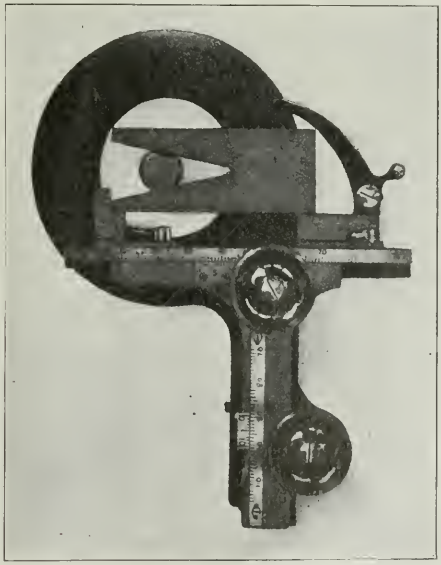


Fig. 4—Mechanical Stage Magnetic Holder and Specimen.

curing a permanent position for the sample. The position of the holder itself is controlled, of course, in the usual way, by means of the graduating devices of the mechanical stage.

Finally, by placing the sample below the stage and bringing the prepared surface on a level with the stage, considerably greater working distance is secured, a gain which has its importance.

SCANDINAVIAN IRON ORES.

Sweden has long been renowned for its rich and pure iron ores and for the quality of metal produced therefrom, and "Norway bars" have been held in high estimation, although no iron has lately been produced in Norway. The older Swedish mines have been exploited in the central and southern parts of that country, but later the Gellivara deposit in northern Sweden was developed and a railroad was constructed connecting it with Lulea on the Gulf of Bothina. Subsequently neighboring deposits—Kurunavaara, Luossavaara and Tuolluvaara were opened, and a railroad constructed across the boundary and through Norway to Narvik, where extensive shipping docks were erected, as described in The Iron Age of January 9, 1908.

Narvik has the advantage of open navigation throughout the year, while at Lulea this is possible for but half the year, conditions prevailing similar to those on Lake Superior. These northern Swedish ore deposits are controlled by the Government, and to conserve them a limit is placed upon the rate at which they can be operated. This limit will approximate 2,200,000 tons in 1910, of which 400,000 tons is expected to be delivered at United States ports. The ores are of high metallic content and are sold without being beneficiated, but they must pay freight charges on transportation for 132 miles to Narvik.

Some rich magnetite is also obtained on the Norwegian fjord north of Narvik, but the expectation that Norway will take an important position in the world's iron ore supply is based upon large deposits of lean magnetite along the Atlantic Coast, which will require beneficiation. Attention was drawn to these a few years ago by a pretentious installation at Dunderland, 80 miles south of Narvik, where a deposit of iron ore was exploited, a railroad being constructed from the Norwegian coast for some 40 miles, and a concentrating plant erected at large expense. The ore, however, did not respond to the treatment which was applied and the enterprise proved unsuccessful. It is understood that an effort may be made to revive this industry by the use of different appliances.

About 20 miles north of Narvik, at Bogen, ore is being magnetically concentrated at the rate of 100 tons per day, and 25 miles further north, at Salangen, another installation of the same character is producing 100,000 tons of concentrates per annum, which are shipped to Germany and there briquetted for furnace use. Close to Tromso, an important Norwegian port further north, is a deposit where it is claimed there are large exposures of lean magnetite which can be cheaply mined and readily concentrated. Abundant water furnishing cheap power for this purpose, and being located on one of the fjords forming the Norwegian channel, this deposit requires no railway transportation, and it is proposed to erect a large concentrating plant, and possibly nodulize or briquette the concentrates.

About 500 miles further north a German-Swedish company is installing a concentrating plant to treat ores obtained at Sydvaranger, at the extreme northeast boundary between Norway and Finland. This plant is expected to be in operation during the coming summer, $3,000,000 having been spent on opening the deposits and constructing concentrating and briquetting works, a part of the equipment coming from the United States. The ultimate capacity is placed at 700,000 tons per annum (100,000 tons being briquetted), most of which will be smelted in German and British furnaces, while some shipments may be made to the United States. This plant is expected to require 40,000 tons of coal per annum, which will be brought from Continental Europe as return cargoes, although it may be possible to employ some of the coal from the island of Spitzbergen.

These lean Norwegian ores average about 35 per cent iron, with only moderate amounts of phosphorus and sulphur, which are much reduced by concentration, as these elements occur mainly as apatite and pyrite, respectively. The iron, as a rule, being strongly magnetic, simplifies the process of concentration. In Scandinavia the wet process is the rule, the ores being finely ground and rich concentrates obtained to economize freight charges. It is claimed that a ton of concentrates can be produced for less than $2, and the estimate of available material for concentration runs into hundreds of millions of tons. It is therefore possible that from the Norwegian fjords large additions to the world's iron ore supply may be expected.

*John Birkenbine in The Iron Age.

An electrical illumination of Mexico City, Mex., will be held during the coming month of September in connection with the centennial of the independence of Mexico. The Mexico Light & Power Co. estimate that about 300,000 extra incandescent lights will be burned during the whole month. Of these, 16,000 will be placed on the Cathedral, 8,000 on the front of the National Palace, and from some hundreds to some thousands on other buildings, public and private.

The exports of manganese ore from Russia during the year 1909 amounted to 611,000 tons, as compared with 440,000 tons in 1908 and 608,000 tons in 1907, showing an advance last year of 171,000 tons over the previous year, and 3,000 tons over 1907.

METALLURGY.

DUCTILE TUNGSTEN AND MOLYBDENUM.*

BY COLIN G. FINK, PH. D.

Tungsten has heretofore been known chiefly as a steel-hardening metal. In recent years, however, it has become an important material for filaments of incandescent lamps, and is today the most efficient metal for the purpose, owing to its high melting point (3000° C.), which is higher than that of any other metal, and its low vapor tension.

It is well known that tungsten is described in all of the text books as a brittle gray metal, and that numerous attempts have been made to reduce it to ductile form, as is evidenced by publications emanating from various research laboratories. Roscoe and Schorlemmer, in the latest edition of their "Treatise on Chemistry," state that "the purest forms of tungsten at present obtainable are hard and brittle and are not ductile, either at ordinary temperatures or when heated."

The metal has ordinarily been obtainable in commerce form of a dark gray powder, usually made by the reduction of yellow oxide by hydrogen or by carbon. This powder, when bought on the open market, is generally impure, and is purified by various well known methods, particularly if the metal is to be used for filaments of incandescent lamps. These filaments have been made on a large scale and are in common use in this country and abroad. Even in ordinary commercial lamps, the filaments are of a degree of purity so high that no impurities can be discovered by the most searching methods of chemical analysis known. Not only is this true, but these filaments, during the course of commercial production, are exposed to temperatures high enough to drive out by mere vaporization almost any impurity.

Nevertheless, these filaments show no traces whatever of ductility, or even pliability, but on the contrary, though strong enough for mounting in commercial lamps, they are exceedingly brittle and incapable of taking a permanent set. Attempts have hitherto been made—but always without success—to produce ductile tungsten by various purification processes, varying the ore from which the tungsten is obtained by trying first wolframite (an iron-manganese tungstate) and then sheelite (the calcium tungstate). Whichever ore is used, it is customary to produce from it the yellow oxide, and a high degree of purity has been sought by repeated precipitations. Various methods of reduction have been tried; among other reducing agents, hydrogen, carbon, aluminum, zinc and magnesium have been used. Reduction has also been effected by electrolytic methods. Since tungsten metal produced in this way has been so pure that no impurities could be detected by ordinary chemical or physical means, and has yet retained its characteristic hardness and brittleness, it has generally been concluded that the metal is entirely lacking in that physical property which is ordinarily termed ductility.

Announcement has recently been made, however, of the production of tungsten in a form in which it is ductile. This ductile tungsten would seem to be a new substance from the point of view of the physical chemist, and it has seemed to me that this society would be interested in learning something of the properties of this product, since only those of us who have been connected with the Research Laboratory of the General Electric Co. have as yet had an opportunity to study it.

Ductile tungsten is a bright, tough, steel-colored metal, which can be drawn into the finest wire, much below one thousandth of an inch. The tensile strength of the wire increases as the drawing proceeds; or, in other words, the more the metal is mechanically worked, the tougher and stronger it gets. In the following table a few figures on the strength of tungsten wires are given. They are the average obtained from a large number of measurements:

TABLE I—TENSILE STRENGTH.

	Tungsten Wire.			
Diam. in mm....	5.0	2.8	1,5	1.2
	0.125	0.070	0.038	0.030
Lbs. per sq. in..	460,000	480,000	550,000	580,000
	to	to	to	to
	490,000	530,000	600,000	610,000
Kg. per sq. mm..	322	336	385	406
	to	to	to	to
	343	371	420	427
	Molybdenum Wire.			
Lbs. per sq. in.....	200,000	230,000	270,000	
	to	to	to	
	260,000	270,000	310,000	
Kg. per sq. mm.....	140	161	189	
	to	to	to	
	182	189	217	

A piece of hard drawn piano wire, tested with the same apparatus, registered, on the average, 507,000 lbs. (35 kg. per sq. mm.), the diameter of the wire being 3 thousandths of an inch (0.075 mm.). According to Schnabel, aluminum shows a similar behavior as regards the effect of drawing: Cast aluminum gives but 17,000 lbs. per quare inch (11.9 kg. per sq. mm.), whereas the drawn metal has a tensile strength of 36,000 to 39,000 lbs. (25.2 to 27.3 kg. per sq. mm.).

The density or specific gravity values of ductile

*A paper presented before American Electro Chemical Society, May 5, 1910.

tungsten likewise increase with the amount of working. The values of ductile molybdenum were also determined at our laboratory.

TABLE II—SPECIFIC GRAVITY.

Tungsten.	Molybdenum.
Before Drawing.	
18.81	10.02
After Drawing.	
Diameter. Inches. mm.	
0.150 3.75. 19.30 to 19.30	10.04
0.010 0.25. 19.58 to 19.64	10.20
0.0015 0.038. 19.86 to 20.19	10.32

Martin (1907) found the density of melted tungsten, analyzing 98.96 per cent pure, to be 16.28; Moissan (1896) and Weiss (1910) give the values of 18.70 and 18.72 for the brittle metal. As is seen from the table, the density increases very appreciably with the amount of mechanical working applied. This same phenomenon is well known in the case of copper, zinc and other metals. The density of cast copper according to Marchand and Scheerer is 8.92, and that of rolled and hammered copper 9.95. Distilled zinc gives 6.92 and wrought zinc 7.25.

The electrical resistance and the temperature coefficient of the two metals are given in Table III. We used the Wheatstone bridge method. The resistance was measured at room temperature and at 170°, employing two oil thermostats.

TABLE III.

Resistivity (25°) in microhms per cu. cm.	Temp. Coeff., per degree between 0° and 170° C.
Tungsten *d.* 6.2	0.0051
a. 5.0	
Molybdenum *d.* 5.6	0.0050
a. 4.8	

The values marked *d* are for hard drawn wire; those marked *a* were obtained after annealing. This resistivity value for tungsten is a good deal lower than that given by Gin (Trans. Am. Electrochem. Soc. XIII, 483). The coefficient for copper (0° to 160°) is 0.00445 (Reichardt); the registry values for copper are 1.62 for the hard drawn and 1.58 for the annealed wire.

The hardness of both tungsten and molybdenum depends very much upon the amount of mechanical working to which the metals have been subjected, and also upon the presence of impurities. Whereas the hard varieties scratch glass, the soft varieties are easily cut with a file.

The thermal coefficients of the two metals were determined on wire 5 thousandths of an inch in diameter. A reading of one degree or the scale was equivalent to an elongation of the wire of 0.000545 inches. The values obtained are $336 \times 10_n^{-8}$ for tungsten and $360 \times 10_n^{-8}$ for molybdenum, the temperature range being 20°—100°. The platinum value for the same range is $884 \times 10_n^{-8}$ (Dulong and Pitit).

Chemically, the two ductile metals behave similarly in many respects. The drawn wire retains its lustre almost indefinitely. Both metals are readily attacked by fused oxidizing salts, such as $NaNO_3$, $KHSO_4$ and Na_2O_2. Acids (HCl, HNO_3, H_2SO_4) attack tungsten very slowly, but molybdenum rather readily. I have heated fine drawn tungsten wire in a mixture of chromic and sulphuric acids for sixteen hours, but could detect only a very small loss in weight.

Original weight: 16.7330 grams; after 16 hrs., 16.7329 grams.

Original weight: 1.3638 grams; after 14 hours, 1.3635 grams.

Apparently the metal becomes passive just like iron.

THE MALM PROCESS FOR THE DRY CHLORINATION OF SULPHIDE ORES.*

The latest practice in dry chlorination is represented by a process used by the Western Metals Co., of Denver, Colo., for the treatment of complex sulphide ores. This process introduces no particularly new applications of the chemical principles involved in former well known processes. However, in its entirety, it differs from all other methods. The present state of development of the mechanical and chemical features of this process is due to Mr. John L. Malm, of Denver.

In the Malm Process, or Western Metals Process, as it is sometimes called, the ore is suitably crushed, dried and subjected to the action of chlorine gas. The metals are converted into chlorides which are dissolved, and separated by methods of substitution. The zinc chloride is dissociated in an electrolytic cell of special design and the chlorine gas is recovered for reuse.

This process is described more in detail as follows:

Crushing.—The ore is reduced to a suitable size. Ordinary average ores amenable to this treatment must be crushed to sizes varying from 10 to 20 mesh. The reduction required depends on the nature of the ore and must be sufficient to expose the sulphide minerals to the action of the chlorine gas. Some heavy sulphide ores may require little or no reduction. Ores whose valuable minerals are distributed through a silicious gangue may require fine crushing. Some lean ores may justify preliminary dressing or rough separation of valueless gangue. Concentrates, middlings and some other products of concentration may require no further reduction.

Drying.—The ore must be thoroughly dried. Practically all of the mechanically admixed moisture should be removed. A certain amount of hygroscopic moisture cannot be removed by ordinary means, but this does not interfere with the process. Whether the drying is performed before or after the final crushing depends on the nature of the material treated.

Treatment in Tube.—The properly prepared ore is

*From a paper by Harry J. Wolf in the Western Chemist and Metallurgist.

fed to a revolving tube of special design, in which it is subjected to the action of chlorine gas. Additional grinding may be effected in the tube by introducing pebbles, when such further reduction may prove desirable. The pulp is fed continuously into one end of the tube and discharged at the other. The chlorine gas is admitted to the tube at the discharge end. The pulp is kept in contact with the gas long enough to chloridize from 40 per cent to 70 per cent of its metal contents. The reaction between the gas and the sulphides is exothermic. By proper regulation of pulp and gas supplies, or the addition of air to the apparatus, the temperature due to the chemical reaction can be controlled and adjusted. By regulating the temperature and extraction, the process can be carried on without producing either sulphur mono-chloride (S_2Cl_2) or plastic sulphur (S_2), which are highly objectionable and whose presence would prohibit the commercial treatment of many ores by this process.

Most of the reactions in the tube are comparatively simple. The chloridization of native gold may be expressed by the simple equation:

$2Au + 3Cl_2 = 2AuCl_3$.

There seems to be a difference of opinion regarding this action. Some investigators claim that metallic gold is not attacked by dry chlorine gas and passes out of the tube unaltered. On the other hand it is held that the gold is only apparently unattacked and that gold chloride is formed but promptly reprecipitated in the presence of ferrous chloride. In any event it is known that the gold is thrown down at once in the aqueous agitator solution containing ferrous chloride.

Should an ore contain such a mineral as sylvanite, the following equations might express the reaction:

(Au.Ag) $Te + 6Cl_2 = AuCl_3 + AgCl + 2TeCl_4$

(Au.Ag) $Te_2 + 4Cl_2 = AuCl_3 + AgCl + 2TeCZ_2$

Native silver is readily attacked thus:

$2Ag + Cl_2 = 2AgCl$

A simple sulphide, such as argentite, in an excess of chlorine, may give rise to the formation of sulphur mono-chloride thus:

$2Ag_2S + 3Cl_2 = 4AgCl + S_2Cl_2$

However, as the mono-chloride comes in contact with more mineral, its chlorine is utilized thus:

$Ag_2S + S_2Cl_2 = 2AgI + 3S$

The last two equations might be combined:

$Ag_2S + Cl_2 = 2AgCl + S$

The mineral hessite no doubt behaves similarly to sylvanite:

$Ag_2Te + 3Cl_2 = 2AgCl + TeCl_4$

$Ag_2Te + 2Cl_2 = 2AgCl + TeCl_2$

The probable behavior of such minerals as the sulpharsenide, proustite, and the sulph-antimonides, pyrargyrite and stephanite, may be expressed thus:

$2Ag_3AsS_3 + 9Cl_2 = 6AgCl + 2AsCl_3 + 3S_2Cl_2$

$Ag_3AsS_3 + 3S_2Cl_2 = 3AgCl + AsCl_3 + 9S$

$Ag_3AsS_3 + 3Cl_2 = 3AgCl + AsCl_3 + 3S$

The reactions with chalcocite may be expressed as follows:

$2Cu_2S + 5Cl_2 = 4CuCl + S_2Cl_2$

$Cu_2S + 2S_2Cl_2 = 2CuCl_2 + 5S$

$Cu_2S + 2Cl_2 = 2CuCl_2 + S$

The minerals chalcopyrite and bornite behave similarly. Taking the former as an example we have:

$2CuFeS_2 + 7Cl_2 = 2CuCl_2 + Fe_2Cl_6 + 2S_2Cl_2$

$2CuFeS_2 + 5S_2Cl_2 = 2CuCl_2 + Fe_2Cl_6 + 14S$

The sulph-arsenide, enargite, and sulph-antimonide, tetrahedrite, behave similarly to the corresponding silver minerals.

Galena gives rise to the simple reactions:

$2PbS + 3Cl_2 = 2PbCl_2 + S_2Cl_2$

$PbS + S_2Cl_2 = PbCl_2 + 3S$

$PbS + Cl_2 = PbCl_2 + S$

Pyrite gives rise to two sets of simple reactions but the ultimate result of the chloridization is ferric chloride:

$FeS_2 + 2Cl_2 = FeCl_2 + S_2Cl_2$

$FeS_2 + S_2Cl_2 = FeCl_2 + 4S$

$FeS_2 + Cl_2 = FeCl_2 + 2S$

$2FeS_2 + 5Cl_2 = Fe_2Cl_6 + 2S_2Cl_2$

$2FeS_2 + 3S_2Cl_2 = Fe_2Cl_6 + 10S$

$2FeS_2 + 3Cl_2 = Fe_2Cl_6 + 4S$

$2FeCl_2 + Cl_2 = Fe_2Cl_6$

The other iron minerals of commercial importance are readily chloridized. The manganese minerals react in most respects similarly to the iron minerals.

Calcium minerals whose heats of formation are higher than that of the chloride, such as calcite, fluorite and anhydrite, remain unaltered in the tube.

The equations expressing the chloridization of the zinc minerals are simple. Those for sphalerite are:

$2ZnS + 3Cl_2 = 2ZnCl_2 + S_2Cl_2$

$ZnS + S_2Cl_2 = ZnCl_2 + 3S$

$ZnS + Cl_2 = ZnCl_2 + S$

The behavior of the sulphur set free in the above reactions is interesting. With the supply of chlorine properly regulated, very little sulphur escapes from the tube as sulphur chloride, but passes out as metallic sulphur with the gangue. Some sulphur escapes as sulphur dioxide gas, the quantity depending on the amount of moisture admitted with the chlorine gas. In an atmosphere of excess chlorine, part of the sulphur is chloridized:

$S_2 + Cl_2 = S_2Cl_2$

However, with the proper adjustment of chlorine and ore supplies this mono-chloride is immediately utilized in chloridizing fresh metallic sulphides.

It is evident that the sulphides may be chloridized in two ways, viz.: by free chlorine gas directly and by the chlorine carried by sulphur mono-chloride. It is probable that both actions take place in the tube but just where one action stops and the other begins is subject to question. After the action in the tube is under way, there is no evidence to show that the chloridization is not entirely effected by the chlorine of the sulphur chloride and that the chlorine gas admitted

to the tube is first combined with sulphur, acting as a carrier, which delivers the chlorine to the metals of the sulphides and then makes its exit with the gangue. This proposition leads to the theory that there are zones of chloridization in the tube whose positions are subject to shifting brought about by the adjustment of the ore and chlorine supplies.

To illustrate this conception more specifically, imagine the tube in operation under normal conditions. At the upper or feed end of the apparatus crushed ore enters while air and gaseous products free from chlorine escapes. At the discharge end of the cylinder a mixture of dry chlorine gas and air enters while gangue and sulphur are discharged. The action inside the tube may be divided theoretically into five zones, thus: the first zone contains a mixture of dry crushed sulphide ore and gaseous products containing a little or no chlorine; the second zone contains unchloridized ore in excess together with ore in process of chloridization by sulphur mono-chloride; the third or middle zone contains ore in process of chloridization by both sulphur chloride and free chlorine gas; the fourth zone contains ore in process of chloridization by chlorine gas direct, together with liberated sulphur in the act of combining with chlorine to form the mono-chloride; the fifth and last zone contains gangue, from which 40 per cent to 70 per cent of the metals have been extracted by chloridization, carrying mechanically metallic sulphur in quantity too great for absorption by the quantity of chlorine gas present which has just entered the tube.

It is unnecessary to state that, in the above hypothetical picture, there is no distinct line of demarcation between the so-called zones, but that these zones blend one into the other. The important point to be emphasized is that the zone containing sulphur chloride must not be allowed to reach the discharge end of the tube.

Agitator Treatment.—When the chloridization in the tube has been carried far enough to suit the requirements of the particular ore under treatment, the partially chloridized ore is passed from the tube into an agitator tank, preferably of the Hendryx type, where it is agitated in water or mill solutions, in the presence of free chlorine gas. Extraction is thereby completed and all the metal chlorides pass into solution.

The partial chloridization carried on in the tube delivers the copper and iron to the agitator in the "ous" chloride condition, viz.: cuprous chloride (Cu_2Cl_2) and ferrous chloride ($FeCl_2$). The "ic" chloride conditions of these metals viz.: cupric chloride ($CuCl_2$) and ferric chloride (Fe_2Cl_6), are formed only in an atmosphere of excess chlorine, or after all the other metals have been chloridized.

In the agitator the ferrous, cuprous and lead chlorides and the chlorides of the other metals chloridized in the tube, which are soluble either in water or in solutions of the other chlorides, pass into solution. On the addition of chlorine to these solutions in the agitator, the "ous" chlorides are converted into the "ic" chlorides. These "ic" chlorides then attack the free sulphides, oxides and carbonates which were unattacked in the tube, and react with them to form chlorides at the same time reducing themselves again to the "ous" condition. By the prolonged addition of free chlorine the "ous" compounds are again oxidized to the "ic" salts and the above cycle of reactions continues until all the metals present are chloridized to the "ic" condition. In addition to the sulphides, the oxides and most of the carbonates of the metals, and the native metals, are chloridized by the "ic" chlorides and pass into solution.

When the charge from the tube reaches the agitator any sulphur mono-chloride which may have been mechanically carried from the tube is at once broken down:

$$2S_2Cl_2 + 2H_2O = 4HCl + SO_2 + 3S$$

Filterpressing.—When all the metals have passed into solution, which is indicated by the fact that the "ic" compounds remain permanently in the "ic" condition, the pulp and solutions are withdrawn from the agitator and passed to properly designed filter-presses constructed of suitable material. The gangue, which will ordinarily consist of silica and sulphur, is filtered from the solution. If desirable the metallic sulphur may be recovered.

Recovery of the Metals.—The gangue may be retorted in the absence of air and the sulphur distilled in the form of flowers of sulphur, or the sulphur may be recovered from the gangue by liquation.

The total metal chloride solution from the filter-press is circulated through a suitable vessel in the presence of metallic copper, which precipitates the gold and silver. The precipitate is allowed to settle and the solution is decanted, or the precipitate is removed in a filter-press. This recovery is indicated by the following equations:

$$2AuCl_3 + 3Cu = 3CuCl_2 + 2Au$$

$$2AgCl + Cu = CuCl_2 + 2Ag$$

In the presence of ferrous sulphate:

$$2AuCl_3 + 6FeSO_4 = Fe_2Cl_6 + 2Fe_2(SO_4)_3 + 2Au$$

The solution from which gold and silver have been recovered, is circulated in a suitable vessel in the presence of metallic iron, which precipitates the copper.

$$CuCl_2 + Fe = FeCl_2 + Cu$$

$$Cu_2Cl_2 + Fe = FeCl_2 + 2Cu$$

The precipitate is recovered by decantation or filtration.

The solution from which gold, silver and copper have been recovered, is circulated in a suitable vessel in the presence of metallic zinc, which precipitates the lead.

$$PbCl_2 + Zn = ZnCl_2 + Pb$$

The precipitate is recovered by decantation or removed in a filter-press or on a suitable filter medium.

The solution from which gold, silver, copper and lead have been removed, contains the iron as ferrous

chloride. While the total metal chloride solution contained the iron as ferric chloride, this was reduced to ferrous chloride, in the foregoing operations by reaction with the various metals with which it came in contact. The solution is agitated in the presence of chlorine gas, to convert all the ferrous chloride to ferric chloride. Then on further agitation in the presence of zinc oxide the iron is precipitated as ferric oxide.

$2FeCl_2 + Cl_2 = Fe_2Cl_6$

$Fe_2Cl_6 + 3ZnO = Fe_2O_3 + 3ZnCl_2$

The precipitate is recovered in the usual way.

The solution from which gold, silver, copper, lead and iron have been recovered, is agitated in the presence of zinc oxide and chlorine gas, which precipitates the manganese as manganese dioxide.

$2MnCl_2 + Cl_2 = Mn_2Cl_6$

$Mn_2Cl_6 + 3ZnO = Mn_2O_3 + 3ZnCl_2$

$MnCl_2 + Cl_2 = MnCl_4$ (unstable)

$MnCl_4 + 2ZnO = MnO_2 + 2ZnCl_2$

The Mn_2O_3 and Mn_2 are recovered by decantation or filtration.

The solution which contains any calcium as calcium chloride is agitated in the presence of zinc oxide and sulphur dioxide, which precipitates the calcium in the form of calcium sulphate.

$CaCl_2 + 2ZnO + SO_2 + Cl_2 = CaSO_4 + 2ZnCl_2$

The precipitate is removed in the usual way.

The solution is concentrated and evaporated to dryness. The residue of zinc chloride is heated to fusion. The fused zinc chloride is delivered to zinc chloride decomposition cells where it is decomposed into molten zinc and chlorine gas.

$ZnCl_2 = Zn + Cl_2$

The molten zinc is drawn from the cells. The chlorine gas is cooled to the proper temperature for reuse in the tube.

There are numerous modifications of the above outline to suit different ores, but the description given practically covers the procedure under normal conditions. The mechanical features of manipulation throughout the process are highly interesting and important but lack of space prevents dilation on these details.

Production of Reagents.—After the process is in operation under ordinary normal working conditions the bulk of the chlorine supply used in the tube is obtained from the zinc chloride decomposition cells. It must be observed, however, that the demand for chlorine gas is subject to fluctuation, not only when changing from one ore to another, but frequently during the treatment of a single ore. The relatively slight variation in the demand for chlorine during the treatment of a single class of ore is readily taken care of by a suitable method for storing the gas.

A satisfactory and novel method of meeting this demand is to carry in the plant a stock supply of chloridized ore, which acts as a storage reservoir for chlorine between the tube and agitator treatments. This provision serves to conserve the gas when a change is made from an ore relatively rich in sulphides to a leaner ore, and when a change is made in the opposite direction the supply of gas may be regulated by drawing upon this storage.

This system compensates also for direct losses of chlorine gas. These losses are of two kinds, viz.: chemical and mechanical. The former are due to the formation of certain insoluble compounds involving chlorine and the latter include all forms of leakage. Neither loss is serious. The chemical loss is very slight while the mechanical losses are reduced to a minimum by handling and conducting the gas by highly efficient methods.

It will be observed that while the process is designed to be cyclic or regenerative so far as the chlorine is concerned, an external source of supply must be provided to cover possible emergencies. This external supply may be derived from one of the approved types of electrolytic salt decomposition cells. The cells thus far investigated by the Western Metals Co. for this purpose, while they accomplish the result for which they are designed, are subject to much improvement from a commercial standpoint. The demand for this type of apparatus as a generator of chlorine gas will no doubt result in its satisfactory development. The cell which appears to offer the most satisfactory solution at this time is a mercury cell invented by Mr. Chas. E. Baker, of Cleveland, Ohio. Briefly, the principal features of this cell are: a graphite anode, a sodium chloride electrolyte and a mercury cathode. The cell has been operated under a pressure of 4 to 5 volts and a current of 300 to 600 amperes. The electrolyte is kept in circulation and a standard density is maintained. The cathode is denatronized by carbon containing an admixture of iron, in the presence of the solution of the sodium hydroxide produced. The hydrate is maintained at an approximately uniform density and the caustic soda is recovered as a by-product.

The zinc oxide, used in connection with recovery of iron and manganese and the removal of calcium, is obtained by roasting zinc ores.

The sulphur dioxide used in connection with the removal of calcium is obtained from the tube or the roasting furnace, or both.

Costs.—From 60 per cent to 70 per cent of the cost of operating this process is for electric power. Direct current at relatively low pressure is used for the electrolytic work. The consumption of power varies with the metal contents of the ore. In practice an actual recovery has been made of 14.2 to 14.4 pounds of zinc per horse-power day.

It is only claimed that 90 per cent of the metals may be recovered from an ore by this process. However, actual practice has demonstrated that in some ores a higher recovery may be depended upon.

The great advantages of the Malm process are:

1. High recovery of the metals.
2. Lower cost per ton for treatment.
3. Applicability to ores commercially untreatable by customary methods.
4. Simplicity.

Results Obtained.—Several classes of complex ore have been successfully treated by this process on a commercial scale. The following example will serve to illustrate the recoveries obtained.

The crude are assayed as follows:

Gold	0.18 oz. per ton.
Silver	13.97 oz. per ton.
Lead	4.78 per cent.
Copper	0.68 per cent.
Zinc	9.00 per cent.

The average value of this ore at present metal quotations is about as follows:

0.18 Oz. Gold	@	$20.00 per oz.	=	$ 3.60
13.97 Oz. Silver	@	50 cents per oz.	=	6.98
4.78 % Lead	@	4 cents per lb.	=	3.82
0.68 % Copper	@	13 cents per lb.	=	1.77
9.00 % Zinc	@	5 cents per lb.	=	9.00
Total value per ton			=	$25.17

The actual average recovery of the metals from the above ore while treating 15 tons per day was as follows:

Metal	Extraction.	Weight.		Recovered Per ton.		
Gold	90%	0.162	oz. @	$20.00	=	$ 3.24
Silver	91.6%	12.796	oz. @	50c	=	6.40
Lead	97.4%	93	lbs. @	4c	=	3.72
Copper	99.3%	13.5	lbs. @	13c	=	1.75
Zinc	94.2%	169.5	lbs. @	5c	=	8.47
Total recovery per ton					=	$23.58

The average cost per ton on this ore, including all charges was calculated as follows:

Mining, tramming and general expense	$ 4.00
Entire cost of treatment	5.32
Royalty	.85
Handling and loading product	.05
Freight charges	1.68
Marketing charges	1.02
Miscellaneous	.65
Total	$13.57

The average profit per ton was $10.00.

It is interesting to note that by the old methods of concentration followed by smelting, the gross proceeds on this ore were $10.75 per ton while the total costs per ton were about $8.85. The resulting average profit per ton was about $1.90.

According to U. S. Consul George E. Chamberlin, of Swatow, China, a company with a capital of 2,000,000 taels ($1,146,000) has been formed in Yunnan to develop the tin mines of that Province. Under the old system some 360 tons of ore has been mined annually.

TRIAL RUNS WITH THE GARRETSON FURNACE.*

By CLARENCE C. SEMPLE.

There appeared in the Engineering and Mining Journal of April 16, 1908, an article by the late Oliver S. Garretson relating to the furnace of his invention, in which he proposed reducing sulphide copper ores to metallic copper in one operation. This article was published after Mr. Garretson's death and dealt principally with the chemical and heat reactions involved. So far as I am aware, nothing has been publishd giving the details of the actual operation, wherefore the following notes on the results obtained in some experiments made with this furnace at Ore Knob, N. C., in the summer of 1905 may be of interest.

The principle of the furnace was based on the assumption that if an ordinary copper-matting furnace were provided with a crucible somewhat deeper than usual, and a suitable blast of air were blown into the bath of matte in the crucible, the iron and sulphur would be oxidized, as the grade of the matte raised, and the heat evolved would be available for the melting of more ore with attendant production of more matte to keep the crucible filled. The sulphur would escape upward through the charge and be carried off through the furnace stack, the oxidized iron would enter the slag and the matte in the crucible would be raised in copper content until metallic copper could be tapped.

DESCRIPTION OF THE FURNACE.

In the Ore Knob furnace, a cast-iron base plate, 2 in. thick, 42 in. wide by 108 in. long, was supported upon 10 cast-iron columns, 18 in. high. The sides and ends of the furnace consisted of two rows of water jackets. These jackets were of cast copper ¾ in. thick with a 4-in. water space. There were 18 jackets on each side of the furnace, 8 in the lower row and 10 in the upper. Each of these jackets were 12 in. wide by 4 ft. 6 in. high. The ends of the furnace were built up of water jackets similar to those used on the sides except the middle lower jacket at each end of the furnace was 16 in. wide. One of the wide end jackets was provided with a tap notch for drawing the matte from the crucible of the furnace and the wide jacket at the other end was fitted with slag notch and spout. There were seven jackets at each end of the furnace, four 12-in. jackets in the upper row, two 12-in. and one 16-in. in the lower row.

The upper 6 in. of the lower jackets overlapped, on the inside, the lower 6 in. of the upper jackets. The overlapping areas of the jackets were planed true and through each passed two 2-in. holes. The cooling water entered at the botom of the lower jackets, rose in them, passed through the two holes into the upper jackets and from the upper part of the upper jackets entered a 5-in. pipe leading to a steel tank outside the furnace building, the bottom of which was a little higher than the top of the upper jackets. The excess of water overflowed from the steel tank. The tank was

*From the Engineering & Mining Journal.

provided so as to insure the jackets always being filled with water.

The lower side jackets of the furnace were each provided with two tuyere openings of 2-in. diameter, the centers being 18 in. above the base plate of the furnace. These tuyeres were called the "smelting tuyeres." Twelve inches below the smelting tuyeres, each jacket was provided with three other tuyeres, 11/16 in. in diameter, which were known as the "converting tuyeres."

The discharge lip of the slag spout was 14 in. above the base plate of the furnace, and arranged to trap the blast in the usual manner. The tap notch in the wide center jacket at the other end of the furnace was 6 in. above the base plate.

The hood of the furnace was built of brick and supported on three sets of 16-lb. rails. There were two stacks in the hood, each 30 ft. high and 37 in. in diameter. A steel feed plate 12 in. deep held the upper jackets in place and added a foot to the depth of the furnace. The furnace had the form of two rectangular prisms, the larger above the smaller. The overlapping of the jackets resulted in there being a 6-in. shelf-life projection all around the inside of the furnace. There was no bosh whatever. The lower prism measured inside the furnace, 29 in. wide, 108 in. long and 54 in. deep; the upper, 41 in. wide by 120 in. long by 48 in. deep so that including the depth of the feed plate the distance from feed floor to base plate was 9 ft. 6 in. There were 16 smelting tuyeres and 24 converting tuyeres on each side of the furnace. The bottom of the furnace was made by tamping in a 6-in. layer of brasque.

The forehearth was water jacketed and lined and bottomed with fire brick, the dimensions inside the brick being 52 in. in diameter by 36 in. deep. The forehearth was provided with a slag overflow, and a tap notch 6 in. above the bottom.

OPERATION OF THE FURNACE.

Blast was supplied to the smelting tuyeres by a No. 3 Roots blower. The converting tuyeres were supplied with air by a Laidlaw-Dunn-Gordon compressor capable of supplying 2,400 cu. ft. of free air per minute up to a pressure of 18 lb. The smelting and converting tuyeres were supplied through independent blast pipes.

The ore used was taken from the old waste dumps of the Ore Knob mine, carefully picked over and broken to 3-in. size. All fines were carefully screened out. A typical analysis of the ore showed: Copper, 1.4 per cent; alumina, 3.03; silica, 12.5; iron, 41.7; lime, 6.8; sulphur, 26. The ore was a heavy pyrite ore composed of the minerals pyrite, pyrrhotite, chalcopyrite, quartz and a small amount of calcite. Connellsville coke was used for fuel and the only flux was an almost pure white quartz taken from the creek bottoms.

After thoroughly drying the brasque bottom, a wood fire was kindled and a bed of burning coke built up to about 12 in. above the tops of the smelting tuyeres. The converting tuyeres, slag and matte taps were plugged and the blowing-in charges fed. These blowing-in charges were made up of first 6,000 lb. of slag, followed by 400 lb. of coke, and 2,000 lb. of slag until three such charges had been fed, then the regular ore charges of 2,000 lb. of ore, 200 lb. of quartz and 7 per cent coke were fed until the furnace was three-quarters filled. Blast was then supplied at 10-oz. pressure through the smelting tuyeres and gradually raised to a maximum of 30 oz., two hours after the first had been turned on.

As soon as the forehearth had half filled with matte and the regular ore charges had reached the zone of fusion, the amount of quartz on the charge would be raised to 400 lb. per ton of ore and the coke cut to 4 or 5 per cent of the charge. It would take about 40 min. for this charge to reach the fusion zone, then the converting tuyeres would be opened at a pressure of about 10 or 8 lb. Before opening the converting tuyeres the furnace would smelt at the rate of about 125 tons of charge per 24 hours; after putting on the converting blast the smelting would run slower for about 40 min. then increase to the rate of 175 to 200 tons of charge.

BRIDGING OF CHARGE.

In the first experiments, we had great trouble usually about six hours after turning on the converting blast. An arch of chilled material would form across the furnace about 2 ft. above the level of the smelting tuyeres, eventually stopping the blast entirely and freezing the furnace completely.

By taking down the end jackets we could have a good view of this arch and generally found it hung with stalactites of material which upon analysis proved to have the composition of Fe_3O_4. We were rarely troubled with an actual chill in the crucible of the furnace, the chills being generally confined to the formation of the arch above the smelting tuyeres. We did have much trouble in keeping the converting tuyeres open; before turning on the converting blast, slag and matte would chill around the lower tuyeres and form noses that were hard to break off when we wished to open the converting tuyeres. These noses would also form nuclei of chills around the lower tuyeres which would not spread so as to fill the crucible but upon being broken off would soon build up again.

Apparently the trouble was caused by the lack of silica to combine with the iron oxide formed by the conversion of the matte at the moment of opening the lower tuyeres, and also due in part to the chilling effect of the jackets on that part of the matte immediately surrounding the converting tuyeres. Lining the crucible was then tried. A mixture of broken quartz, with just enough clay to bind the particles together, was rammed between the jackets and a wooden mold in the crucible of the furnace. This lining was made 6 in. thick and carried up to within 3 in. of the smelting tuyeres. Holes were punched for the entrance of the converting blast and opposite the slag

notch. After drying this lining the furnace was blown in as before and from that time on we began getting encouraging results.

OPERATING WITH QUARTZ-LINED CRUCIBLE.

After putting in the clay lining a typical run of the furnace would be about as follows: The blowing-in charges as before mentioned were fed, followed by a regular ore charge of 2,000 lb. of ore, 200 lb. of quartz, with 7 per cent coke until the furnace was filled. The blast was turned on through the smelting tuyeres at a pressure of about 10 oz., this being raised to 24 or 30 oz. two hours later. The charge would melt down quickly, the furnace producing about one-half as much matte as slag. The slag, while basic, ran hot and limpid, a typical analysis of which would show: Silica, 34.4 per cent; iron, 37.5; lime, 7.6; alumina, 6.3; sulphur, 0.8; copper, 0.35. The corresponding matte carried 3.2 per cent copper, 60 per cent, iron and 30.4 per cent sulphur. Approximately 60 per cent of the sulphur in the ore went out the stack.

After the regular charge had reached the fusion zone the coke would be reduced gradually to about 3 per cent of the weight of charge. The amount of quartz raised to 400 lb. per ton of ore and as soon as the slag began to show acid the converting tuyeres would be opened at a pressure of 8 lb., gradually raising it to 10. The immediate effect of opening the lower tuyeres would be to cause slower running for about an hour, then the furnace would begin to run faster until it took about 50 per cent more charge than when running with the smelting tuyeres alone. The clay lining would be gradually eaten away and completely disappear in 40 minutes, but by that time conditions in the crucible would be such that no chills would form in front of the tuyeres and we could shut them off and open them again at will.

DARK TUYERES.

Soon after the lower tuyeres had been opened the smelting tuyeres would darken and in spite of constant punching could not be kept open nor could any blast be driven into the furnace through them. A bar could be driven from a smelting tuyere on one side out through the tuyere opposite and be withdrawn with the bare hand. The smelting blast was cut off altogether after the tuyeres had darkened, but the furnace ran exactly as well with only the lower tuyeres in commission.

About an hour after the lower tuyeres were put in blast no matte at all could be observed overflowing with the slag. In 24 hours we would hardly tap a pot of matte from the forehearth. With 400 lb. of quartz to a ton of ore and with the converting blast on, a slag would be obtained showing the following analysis: Silica, 37.4 per cent; iron, 38.7; lime, 5.4; alumina, 3.2; sulphur, 0.5; copper, 0.15. The corresponding matte ran 9.8 per cent copper.

Shortly after opening the lower tuyeres, the quartz on the charge would be again raised to 600 lb. per 2,000 lb. of ore and the slag obtained showed: Silica, 39 per cent; iron, 38.5; lime, 3.9; alumina, 2.5; sulphur, 0.4; copper, 0.2. The coke was oftentimes reduced to 0.95 per cent, and one time we ran for five hours with no coke at all.

The slags ran from the furnace white hot and smoking. They were very limpid, cooled exceedingly slowly in the pots and usually showed a glassy surface or fracture when cold, and although rather high in iron, the little matte that came over in the slag seemed to settle rapidly and cleanly. Both the slags and mattes were magnetic, and could be entirely lifted with a magnet when ground to powder.

FURNACE CONDITIONS.

The furnace always ran with a cold top showing no signs of fire, the charge was kept level with the feed floor and great volumes of bluish and yellowish-white smoke rose to tax the carrying capacity of the stacks. This sulphur smoke would often settle about the smelter yard to the great annoyance of the slag wheelers who oftentimes could not work more than half the shift. It was often possible to account for only 2 per cent of the sulphur charged with the ore in the slag and matte obtained, 98 per cent of the sulphur being burned off.

The converting capacity of the furnace often exceeded the rate of matte production so that the line of matte in the crucible would sink below the lower tuyeres, allowing slag to come in front of those tuyeres which would immediately chill and cause trouble. The number of converting tuyeres in blast would then be decreased and charges of old low-grade matte with sufficient quartz to flux the iron be charged until the lower tuyeres were again submerged. We had no trouble with the lower tuyeres as long as they were submerged in matte. The amount of air supplied the furnace was about enough to oxidize all the iron to FeO and three-quarters of the sulphur to SO_2.

COPPER CONTENT OF PRODUCTS.

Samples of the matte and slag taken from time to time after the converting tuyeres were put in blast were analyzed and the copper content is shown in the accompanying table:

COPPER CONTENT OF MATTE AND SLAG.

	Matte. Per cent.	Slag. Per cent.
Before converting began	4.57	0.35
5 hours after converting tuyeres had been in blast	8.08	0.15
17 hours afterward	32.12	0.18
18½ hours	41.75	0.40
20 hours	45.64	0.40
25 hours	56.83	0.42
30 hours	62.29	0.45
In crucible after blowing out	60.25	...

The production of coal in Chile in 1909 amounted in value to 11,686,623 pesos.

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NOTES AND COMMENTS.

Standardized Samples for Analysis.

In the preceding issue, we called attention to the need of standard methods of analysis, so that comparative results could be secured by different chemists working on the analysis of technical products. We also wish to call attention to the need for and the desirability of standard samples of various materials, such as may come into the laboratory for chemical examination.

Even in the best regulated laboratories mistakes will occur from time to time in the standardization of a solution, or in some detail of an analysis which may be overlooked by the operator. When the laboratory has on hand samples of materials, the accurate analysis of which are known, it is easy to carry along the analysis of one of these samples during the examination of an unknown sample of the same class of material. The result thus obtained on the analysis of the standard material will show whether any error has been made in the analysis of the unknown material, bring out not only any mistakes which might have been made in standardizing solutions, but also any faulty manipulations in making the analysis.

Many laboratories doing large quantities of iron and steel analysis have the custom of sending at least one sample of standard iron or standard steel through the laboratory with each set of samples submitted to the laboratory workers, that is; once each day each worker in the laboratory will be called upon to make at least one determination on a standardized sample, he not knowing which one of the samples submitted to him is the standardized one.

The Government Bureau of Standards has prepared samples of various grades of cast iron and steel which may be used in this way. They have also prepared a limited number of samples of other classes of material which are supplied with accurate analyses. It is the function of this article to point out the desirability of a greater variety in such materials, and also the desirability of using them more extensively, particularly in laboratories conducting a large number of examinations of technical products. It is believed that such practice as described above will materially lessen the discrepancies frequently occurring in our technical laboratories.

We should also suggest the more extensive use of standardized samples in the laboratories of our colleges and universities. We are inclined to think that to an extent at least, errors in analysis made by students are not sufficiently looked after and corrected. Many times the composition of materials given them for analysis is not accurately known and if several students agree in their results the instructor accepts this as correct, when probably the students have compared results before handing them in. This can of course be avoided by the use of samples upon which the instructor has an accurate analysis. It has also been our experience that students take a greater interest in their analytical work under these conditions and that they will take the initiative in bringing their results up to a reasonable degree of accuracy.

In some of our schools it is the practice never to give a student a sample for analysis unless the analysis of the material is first accurately known by the instructor. As far as possible standardized samples are used, but where it is impossible to secure these, the samples are analyzed by one or more instructors. It is believed that such practice will aid materially in reducing a number of errors made by young graduates during their first experience in technical laboratories.

This suggestion is given with that end in view.

Warning to Investors.

The state mineralogist of California, Mr. Louis Aubury has recently seen fit to issue a note of warning to prospective investors in California oil lands. The oil fields of California have been developing in a wonderful way in the past few years and as always is the case the legitimate enterprises are accompanied and somewhat hampered by the illegitimate ones. Some of his words of warning are so well taken and apply so thoroughly to other mining industries that we quote from his letter:

"Has the advertising oil company under consideration a title to the alleged oil land being exploited; in what manner and for what consideration was title acquired, and is it actually within proven or unproven territory?"

Many companies operating in *unproven* territory, advertise that they "own" or have "secured" such and such tracts of land; that they are within *proven* oil territory and that the purchase was made for so much of the company's stock in addition to a cash consideration—frequently quite a large one—and added thereto is the payment of a royalty to the owner or owners when production is reached; the latter the only consideration against which the locator of the land will ever have any claim, and that a remote one.

"Are the officers of the company you have under consideration in good standing? Obtain a report on them from some commercial company."

The most extensive fake operators have followed

their nefarious practice continuously for years during which time they have repeatedly been roasted and fully exposed by the newspaper in all parts of the country. Notwithstanding this they regularly incorporate company after company just as fast as the old ones play out and with the same result, a certain class of the investing public never failing in its desire to contribute to the purses of these worse than highwaymen.

In addition several other points are referred to as worthy of the most careful investigation—such as whether the company in question is overcapitalized; are commissions deducted from the sale of stock, and what are the salaries paid the officers of the company (in fake companies, of course, the promoters), all of which questions involve the scheme of such operators to make the company a paying proposition—for themselves.

RECENT PATENTS.

The following patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill Building, 908 G street, N. W., Washington, D. C.

963,111. Process of Treating *Precious-Metal-Bearing Materials*. Paul W. Avery and Eugene C. Knowles, Deadwood, S. D., July 5, 1910.

963,123. *Electrical-Resistance Alloy*. John T. H. Dempster, Schenectady, N. Y., July 5, 1910.

This is an electrical resistance conductor comprising iron, nickel, chromium and manganese, the iron constituting more than 50 per cent of the alloy.

963,156. Method of Making *Aluminum Fluo-Silicate*. Edward F. Kern, Knoxville, Tenn., July 5, 1910.

The process consists in mixing aluminum silicate, silica and hydrofluoric acid in approximately molecular proportions in the presence of water.

963,174. Process of Making *Concentrated Sulfuric Acid*. Otto Proelss, Kansas City, Missouri, July 5, 1910.

963,275. Manufacture of *Alcohol and By-Products* and Apparatus Therefor. Harry O. Chute, New York, N. Y., July 5, 1910.

963,291. Method of Making *Carbonized Fabric*. Frederic L. Horton, Lynn, Mass., July 5, 1910.

963,337. *Artificial Stone*. Thomas Mathieson Thom, Chesbunt, England, July 5, 1910.

963,345. *Metallurgical Process*. Thomas Leopold Willson and Maximillian Matthias Haff, Ottawa, Ontario, Canada, July 5, 1910.

963,806. Manufacture of *India-Rubber* for Elastic Tires of Vehicle-Wheels. Emile Polzot, Glos, near Lisieux, France, July 12, 1910.

963,917. *Paint* and Process of Making the Same. Jules Meurant, Liege, Belgium, July 12, 1910.

963,970. Process of *Bleaching and Aging Cereals*. John Morris Williams, Guthrie, Oklahoma, July 12, 1910.

964,096. Process of *Electroplating*. Thomas A. Edison, Llewellyn Park, Orange, N. J., July 12, 1910.

The process consists in chlorinating a suitable quantity of copper sulfate solution, and adding from time to time in small amounts to the solution in a copper plating bath, as the chlorin becomes exhausted by reaction with the hydrogen developed upon the cathode, the solution being maintained slightly acid.

964,156. Method of Making *Haloids*. James C. Graves, Midland, Michigan, and John P. Simons, Cleveland, Ohio, July 12, 1910.

964,164. Composition of Matter to Be Used for Making *Acid-Proof Cement*. Heinrich Kayser, Darmstadt, Germany, July 12, 1910.

964,255. Method of Handling *Matte*. William D. Kilbourn, Murray, Utah, July 12, 1910.

964,365. *Blasting Powder*. Charles Arnoudts, Guatemala, Guatemala, July 12, 1910.

964,415. Method of Producing *Hydrogen from Water-Gas*. Adolph Frank, Charlottenburg, Germany, July 12, 1910.

The method consists in mechanically separating carbon dioxid, carbon monoxid and other secondary gases from the water gas and then passing the residual gas mixture containing some of said secondary gases over heated carbid.

964,459. Manufacture of *Metallic Silicids*. Georges Strauss, Paris, France, July 12, 1910.

964,483. Manufacture of *Celluloid* or the Like. Thomas Bolas, Chiswick, England, July 19, 1910.

964,566. Manufacture of *Aluminum and Its Alloys*. Heinrich F. D. Schwahn, Belleville, Ill., July 19, 1910.

964,869. Manufacture of *Steel*. Charles Morris Johnson, Avalon, Pa., July 19, 1910.

964,964. *Indurated Cascin Compound*. Byron B. Goldsmith, New York, N. Y., July 19, 1910.

965,016. Process for Producing *Sodium Peroxid* Compositions for Washing and Bleaching Purposes. Paul Roser, Esslingen, Germany, July 19, 1910.

965,098. Process for Separating *Caoutchouc* from Resinous Products. Georges Ferdinand Flamant, Paris, France, July 19, 1910.

965,137. *Indurated Albuminoid Compound*. Byron B. Goldsmith, New York, N. Y., July 19, 1910.

965,142. Method of Making *Silican Carbid*. Frank J. Tone, Niagara Falls, N. Y., July 19, 1910.

The method consists in providing a charge of silicious and carbonaceous material in substantially reacting proportions around a resistance core, supplying electric current to the core, moving the charge and core materials past the electrodes, and continuously supplying the core and charge material in one portion and removing them at another portion.

Three mine rescue stations are to be established at once under the newly created Bureau of Mines of Department of the Interior. According to the announcement of Mr. George Otis Smith, Acting Director of the Bureau, stations will soon be established in the coal mining districts at Birmingham, Ala., Huntington, W. Va., and Wilkes-Barre, Pa. Nine stations are ultimately planned. Each station will be in charge of an experienced foreman whose duty it will be to train the miners in his vicinity in rescue work. The equipment of each station will consist of eight oxygen helmets. Miners trained in the use of these helmets will be organized into rescue corps at each mine and will be held in readiness to answer emergency calls in their own mines and when necessary in neighboring ones. At times of disaster the foreman will have command of these rescue forces. Also a trained mining engineer will be assigned to each district, who will examine into the physical conditions of the mines of his district and have general supervision over the rescue work.

Two serious fires in Chicago on July 24 are stated to have been caused by grain dust explosions. One of these fires was at the plant of the Northwestern Malt & Grain Co. and the other at a brewery. The total loss is estimated to be $300,000.

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THE MANUFACTURE AND INDUSTRIAL APPLICATION OF OZONE.*

By DR. OSCAR LINDER.

Since its discovery in 1840 by Schoenbein, ozone has been a fascinating subject for investigation to many chemists and physicists. The vast commercial possibilities of ozone have been conceived by many scientists and it is interesting to note the prophecy of Berthelot that ozone had an immense future and would ultimately work a veritable revolution in the chemical industry. The scientific literature and the records of the Patent Office will bear proof of the attention which has been paid to this remarkable gas by scientists throughout the world. There have been more than one hundred patents issued by the United States Patent Office on methods and apparatus for producing ozone and the number of foreign patents is legion. It is true that most of them are based on the original method of producing ozone by subjecting air to electrical stresses, and most of the claims are but special arrangements and combinations embodying this fundamental principle, or means for producing the electrical stress. However, there are some notable exceptions, such as for example, methods of producing ozone by means of heat or ultra violet rays, although the efficiency of these processes at the present time is too low to enable them to compete successfully with the electrical method.

PROPERTIES AND OCCURRENCE.

Every chemist and most laymen know that ozone is a gas with the composition O_3, and it is an allotropic modification of oxygen, formed from the latter by an endothermic process. According to Berthelot, 29,600 calories are required to form 1 gram-molecule of ozone from oxygen. Expressed in a popular way, ozone may be called oxygen in a highly energized form. As a gas it occurs, or can be produced, in greatly diluted form, but it can be condensed to a deep blue liquid of a specific gravity of 1.46, which boils at —106° C. according to some investigators, and at —125° C. according to other investigators. It is very unstable in either form, and upon standing, decomposes slowly, if greatly diluted, and may do so explosively if in liquid form. This decomposition increases with a rising temperature and at a temperature above 270° C. ozone cannot exist. Its density as a gas is 1.66, air being 1.

Ozone has a characteristic odor which is perceptible even when in extreme dilutions with air. So delicate is our sense of smell to this gas, that it is easily possible to detect the presence of one part ozone, in about ten million parts air, which would correspond to a concentration of 1/100,000 of 1 per cent. It is the most powerful oxidizing agent known, and will attack, even when greatly diluted, all oxidizable substances, especially organic matter. It is, therefore, a valuable oxidizing agent, not only because of the ease of its application as a gas, but also because no other elements are introduced into the reaction but oxygen.

Ozone occurs in nature in the atmosphere and is supposed to be formed in small quantities through electric conditions of the atmosphere, and by the action of the ultra violet sun rays upon the atmospheric air. The latter formation explains why it is more abundant in the higher regions where the ultra violet rays are largely absorbed by the atmosphere. The quantities in which ozone is present in the atmosphere is largely a matter of conjecture. It has been given as from .1 to 12 parts in 1,000,000 parts by volume of air, but most likely it is present, even where most abundant, in quantities of not more than 1 in 1,000,000. We are not going much wrong if we assume it to be about 1 part in 1,000,000 parts air (1/10,000 of 1 per cent, or a little less than 1 mgr. per cubic meter air). The very fact that even in smaller concentrations than this its presence can be detected distinctly by our sense of smell, while its detection by chemical means is, at best, uncertain, must be taken as an indication of its importance in our daily life.

MANUFACTURE.

Ozone can be made in a number of different ways, but the only method of commercial importance at the present time is its formation through electric stresses. I might mention that a process of great interest and of commercial possibilities is the formation of ozone through the action of ultra violet rays upon air, these rays being produced by means of a mercury vapor lamp enclosed in a quartz tube. Another method of scientific interest is the production of ozone by means of heat in which Nernst & Clement obtained fair yields (as much as 3½ grams of ozone per kilowatt hour)

*A paper presented before the American Institute of Chemical Engineers at the meeting held June 24, 1910, at Niagara Falls, N. Y.

by leading oxygen over incandescent bodies and cooling it immediately by liquid air. F. Fischer obtained equally good results by blowing air at a velocity of 50 meters per second through a slit 1 mm. wide over a Nernst burner and then cooling it in a glass tube surrounded by water. However, at the present time these methods are too inefficient for commercial purposes.

The apparatus designed by Berthelot, a sketch of which is given in Fig. 1, is the prototype of most ozonizers which are on the market at the present time. Occasionally parallel plates are used in place of concentric tubes, but in general there is very little difference between the different designs and makes except as to construction.

There may be either one or two layers of a dielectric material, which is usually glass, free from lead, or mica separating two metal electrodes. The latter are used mostly in the form of aluminum or tin foil pasted to the dielectric or sometimes solid metal or metal brushes, which may or may not touch the dielectric.

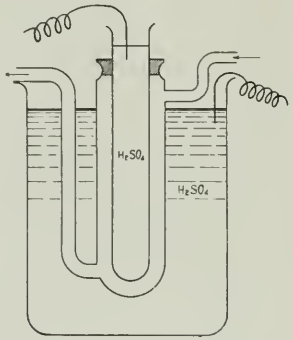


Fig. 1—Berthelot Ozonizer.

The thickness of the dielectric layer is usually in the neighborhood of 3/32 in. and that of the air space about 1/8 in., but these dimensions depend of course, largely on the character of the electric energy. When the metal electrodes are connected to the opposite terminals of an alternating current of suitable frequency and voltage, a so-called cold or silent discharge, free from sparks, takes place through the glass and is visible by a faint violet glow distributed evenly through the air space between the electrodes. The air or oxygen to be ozonized is passed through this glow and is thereby ozonized. It is not definitely known whether it is the stresses themselves which cause the ozonization of the air or whether it is due to the ultra violet rays which are generated in the air gap, but the latter theory seems more probable at the present time. It should be mentioned here that, the use of oxygen instead of air, while giving considerably higher yields and concentrations, has been generally abandoned on account of the costliness of the oxygen. A step up transformer of high ratio and comparatively low current capacity constructed on the principle of potential transformer is always a part of an ozonizer except in cases where induction coils or static machines furnish the electrical energy.

In order to understand the action of an ozonizer, it is necessary to first dwell upon the influence of voltage, heat and moisture on the generation of this gas and upon the relationship between yield and concentration.

The amount of ozone which can be generated in an ozonizer of the Berthelot type is theoretically in direct proportion to the voltage of the discharge per unit of

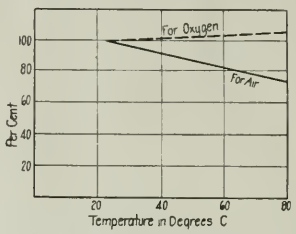


Fig. 2—Relative Production of Ozone at Different Temperatures as Compared with 22° C.

air ozonized. This would be true in practice if it were not for the destructive action of heat on ozone. There is a considerable amount of heat formed in the so-called cold or silent discharge, and the heat thus generated increases of course as the square of the current of the discharge. In using a high wattage of electric discharge per unit of air ozonized, a condition which is necessary in order to obtain the high yields and concentrations required for industrial purposes, it is desirable, therefore, to use as high a voltage and low a current as feasible. Most failures in ozone generators

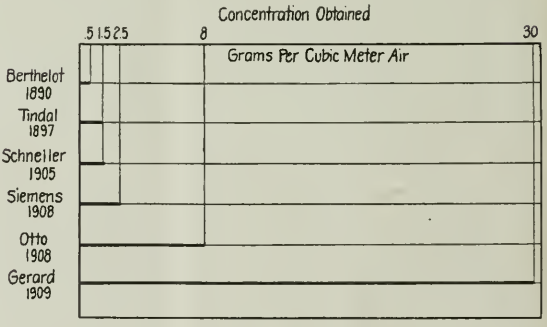


Fig. 3.

are due to insufficient understanding of this principle, the natural tendency of designers being to use as low a potential as possible. There is no good reason for employing low voltages and it is now proven that, contrary to former belief, the formation of ozone is not limited to certain voltages or frequencies. It is only at about 8,000 to 10,000 volts that the process of ozonization becomes economical and apparatuses employing voltage below that are hopelessly low in efficiency for all purposes where both high yields and

concentrations are required. In former years of limited knowledge of high potential transformers and other alternating current machinery made it necessary to use low voltages, but at the present time the design and manufacture of small and efficient apparatus of this kind affords no difficulties, and there is, therefore, no necessity of restricting the voltage employed. Voltages as high as 40,000 volts are now used, and the most successful ozonizers are those which employ high voltages.

The effect of heat on the formation of ozone is illustrated in the diagram show in Fig. 2, which is taken from L. Gerard's treatise on ozone in the August number of the Proceedings of the Societe Belge d' Electricians, 1909, from which you can see that the production rapidly liminishes as the temperature increases. After 80° C. it falls off still more rapidly and at 270° C. it is 0. The importance of keeping the electrodes as well as the air to be treated cool can readily be grasped from this diagram.

The very best designed ozonizers still generate a sufficient amount of heat so that for commercial yields

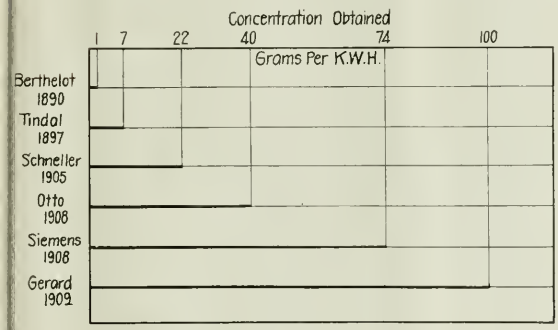


Fig. 4.

and concentrations it becomes necessary to resort to artificial cooling of the electrodes or of the air to be ozonized. Some designers have even resorted to refrigeration of the air before ozonization, and some very good results have been obtained thus, but it should be said that refrigeration is not necessary in small apparatus, if sufficiently high voltages are used, although for low voltage discharges it is perhaps the only means of obtaining anywhere near commercial yields.

The concentration of ozonized air is the amount of ozone expressed in grams contained in one cubic meter air, and is a very important factor in all processes in which ozone is used. The yield of an ozonizer is usually expressed by giving the amount of ozone generated in grams per kilowatt hour electric energy consumed. The latter includes the transformer losses, but no other auxiliary apparatus. Much progress has been made during the last 20 years in both concentrations and yields obtained, as shown in Figs. 3 and 4, which are taken from Gerard's above noted treatise. You will notice that concentrations as high as 30 grams per cubic meter air, which would correspond to 2 per cent by volume, and yields as high as 100 grams per kilowatt hour have been obtained. Quite recently even higher yields have been achieved in an experimental plant built on the Steynis refrigerating system, which is reported to have given never less than 105 grams and sometimes as high as 250 grams of ozone per kilowatt hour at a concentration of about 4 grams.

Unfortunately an ozonizer is, in its action, similar to a storage battery, and it is at the present time impossible to obtain the highest concentration at the greatest efficiency, and an increase in the concentration

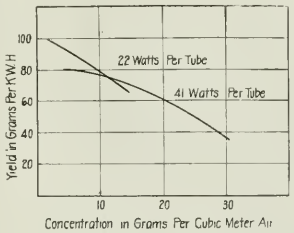


Fig. 5—Relation Between Yield and Concentration of Gerard Ozonizer.

will bring with it a decrease in the yield or vice versa. This is easily understood when the heating effect of the discharge is considered. In running an ozonizer at a high concentration the wattage of the electrical discharge per unit of air to be ozonized must be high and this necessitates a slow rate of flow of the air to be ozonized or a high density of discharge per unit of electrode surface. Both these conditions favor excessive heating of the air during ozonization, and this we have seen is unfavorable to a large yield. On the other hand, in running an ozonizer at a high yield, the

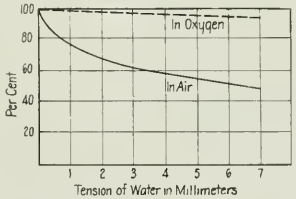


Fig. 6—Relative Production of Ozone as a Function of Humidity.

most effective cooling of the electrodes is necessary and can be best obtained by circulating through the electric glow a large volume of air, resulting of course in lowered concentration (see Fig. 5). It is evident that this relation between concentration and yield, being due to the heating effect of the discharge, will be all the more favorable from a commercial standpoint, the higher the voltage employed.

The density and discharge per unit electrode surface is a factor depending largely on the design of the apparatus and on the voltage and rate of flow of the air through the apparatus. As a general rule it is consid-

ered good practice not to exceed .4 watt per square centimeter electrode surface.

The effect of humidity of the atmosphere on the production of ozone is shown in Fig. 6. The presence, in the air to be ozonized, of water vapor so greatly reduces the production of ozone that for all commercial concentrations except for ventilation it is necessary to dry the air before ozonizing it. This practice is followed in almost all instances and is usually accomplished by passing the air through a tank containing lime before passing it through the ozonizer, or, in large plants, by refrigeration.

It must be understood that where very low concentrations only are required, such as for ventilating cooling or drying of the air. In a well designed apparatus of this kind sufficient cooling is accomplished preferably by the artificial circulation of the air set up and the reduced production of ozone in the presence of such water vapor can be taken care of by making the apparatus adjustable.

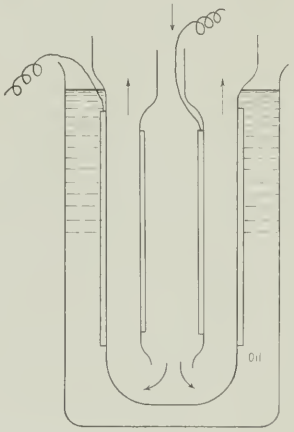


Fig. 7—Gerard Ozonizer.

In subjecting air or oxygen to the effect of electric stresses, it is well known that some other products are formed besides ozone. If water vapor is present in the air or oxygen, there may be some hydrogen peroxide formed. However, the drying of the air before ozonization does away with this possibility. In small ozonizers used for ventilating purposes in which it is not customary to dry the air, the amount of hydrogen peroxide formed is so small and the dilution so great that its presence can be disregarded, especially considering the great similarity in action between hydrogen peroxide and ozone.

Besides hydrogen peroxide there is always formed a more or less small amount of the oxides of nitrogen. Their presence in the ozonized air is highly undesirable and should be carefully avoided. The formation of these oxides is favored by heat, sparks, dust and dirt, and it is therefore important in the construction of ozonizers not only to provide sufficient cooling but also to prevent the formation of disruptive discharges or sparks in place of the cold or silent discharge during the operation of the apparatus. The formation of sparks is favored by the accumulation of dust and dirt in the air space, therefore in the design of ozonizers it is very important that particular attention be paid to the necessity of keeping the air space clean and free from accumulation of dust and dirt. The amount of nitrous oxides formed is, as a rule, very small. In well designed ozonizers there should not be more than 1 or 2 per cent of nitrous oxides formed, figured on the amount of ozone generated. In poorly designed apparatus the amount of nitrous oxides formed may run up to five or ten times this amount.

During ozonization the air to be treated must be kept in positive motion; a fan, blower, or air pump is therefore a necessary accessory of every well designed ozonizer.

In regard to the quantitative determination of ozone it should be said that most of the figures which we find in the literature up to about ten years ago are unreliable, owing to defective methods. At the present time the determination of ozone in the higher concentration does not afford any difficulties, but in low concentrations, such as in the atmospheric air, accurate determinations are even now impossible. For industrial use the method now considered standard is the absorption of ozone by means of a neutral potassium iodide solution. The iodine set free by the ozone is titrated, after acidifying, in the regular way by means of sodium thiosulphate and starch. The hydrogen peroxide which may be found in the presence of vapor in the air to be ozonized is best eliminated by passing the ozonized air over finely divided chromic acid crystals before passing it through potassium iodide solution. For very small concentrations, manganese chloride paper in conjunction with Quajak tincture or Thallium suboxide as recommended by Engler and Wild and also the well known tetra-base paper are giving fair comparative results. They are not, however, accurate enough for determining quantitatively the amount of ozone in the atmospheric air.

It is not the intention of this paper to go into details as regards various apparati for producing ozone, as there are a number of treatises available where this information can be obtained. For example, the book on ozone by Henry Lecoux, the paper on ozone by Leon Gerard in the August number of the Proceedings of the Societe Belge d' Electricions, 1900, the various papers by Ehrlwein, F. Fischer, Warburg, and many others, some of which I mention in this paper. Most plants where a large amount of ozone is consumed have been designed specially to suit the conditions of one particular problem. Therefore there is no such thing as standardization in this line, and the number of designs so far is nearly as great as the number of installations.

The first ozonizer constructed to meet with some success was that of Berthelot in 1800, a sketch of

which is given in Fig. 1. The general principle of this apparatus has not been changed to any great extent by later investigators, although changes in details of construction and the progress in our knowledge of alternating current machinery made it possible for later designers to greatly increase its efficiency.

The best known of the ozonizers of recent date, working on the Berthelot principle, is that designed by the engineers of the Siemans & Halske Co., whose comprehensive investigations and publications have done much to bring the subject to the attention of the technical world. A still more recent design and one which has achieved considerable success is that of Gerard, a sketch of which is given in Fig. 7.

INDUSTRIAL APPLICATIONS.

The industrial application of ozone has been delayed greatly in the past by unusual requirements set up by the manufacturers of such apparatus in regard to the nature of the electric current supply. Until comparatively recently it was necessary to use static machines or induction coils run by primary batteries in order to obtain a discharge of the characteristics recommended by the manufacturers, and even today the use of interrupted direct current or of alternating current of frequencies not met with in practice are prescribed for some apparatus. It is no wonder that under such conditions the use of ozonizers has made slow progress, but fortunately it has been found that the regular alternating current of commercial frequencies can be used just as well, and in most cases to better advantage, than many special forms of electrical energy recommended in the past. Thus it is now possible to purchase ozonizers operating from alternating lighting circuits without further electrical apparatus than a transformer; in places where direct current only is available we can convert it into an alternating current of the desired frequency by means of a small and inexpensive converter, several types of which are now on the market for that purpose. Small ozonizers for ventilating purposes are even made so complete and compact that they can be connected to any electric light socket by means of a screw plug and cord, and they can be obtained for any commercial voltage, either alternating or direct current.

Water Purification.—The subject of water purification by means of ozone has been so extensively treated and discussed in the past that it is not necessary to go into details. The success of this method of water purification has been definitely proven and it has been found that in large installations it is not only much safer and more effective, but also cheaper than quartz filtration, and requires much less space. Those specially interested are referred to a recent treatise on this subject in the Engineering News of April 28, 1910. Large installations for water purification are as a rule designed specially to suit the requirements of one particular problem, therefore the subject can not well be treated generally with other uses of ozone.

The bactericidal properties of ozone, since having been studied and proven by Froehlich and Chimuller, have perhaps been more frequently investigated than any other of its properties, and the fact that bacteriologists like Pasteur, Roux, and Koch have endorsed them has left no further doubt in the minds of the most skeptical persons. Ozone oxidizes the impurities in water and renders them harmless; it clears dirty water and still leaves no compounds harmful to the health or disagreeable to the taste. This purification is accompanied by a distinct phosphorescence of the water. In cases where muddy appearance is largely due to substances of mineral origin, it is customary to partially clear the water by means of a pressure filter before ozonization. At different times it is customary to use about twice as much ozone as is found necessary to thoroughly purify an average sample of the water in the laboratory. The concentrations used for water purification are high and range from 5 to 12 grams of ozone per cubic meter of air, according to the quality of water. The amount of ozone required for purifying one cubic meter of water also varies greatly according to the quality of the water, but may be given as from .5 gram to 10 grams ozone per cubic meter of water. The above figures represent about the limits ever used for purifying water of any kind.

Owing to the low solubility of ozone in water (it is given as from 5 to 10 parts in 1,000 parts water), a very intimate contact between ozonized air and water is necessary, and this is usually accomplished in towers constructed on the principle of the absorbing tower or by sprays and injectors.

There seems to be no close agreement between the figures published about the cost of operation of the water purifying plants now in operation, but a perusal of the data available would show the cost of purifying, including interest, depreciation and maintenance, as being from .1 to .4 cent per cubic meter or from $3.80 to $15 per million gallons, according to the quality of the water to be purified.

Ventilation.—One of the newest fields for the application of ozone is in the ventilation of rooms and buildings. Good ventilation is being appreciated more and more because of the physical comfort which it affords as well as because of its therapeutic and hygienic importance. In all modern buildings, theaters passenger boats, hotels, etc., a ventilating system is an important part of the equipment, and even in places the very name of which is associated with bad air, such as street cars, sleeping cars, tunnels, etc., the feasibility of supplying good air is being seriously studied. Up to the present time the problems of ventilation have mostly been categorically solved by heating or cooling the air to the proper temperature, and in some few cases by filtering it through a sheet of water or a solid filter. Recently, however, the demand has arisen to improve the air by charging it with ozone to a concentration corresponding to the normal percentage found in places noted for the purity and freshness of the atmosphere.

It has been found and demonstrated that the presence of ozone in air in small quantities has a beneficial physiological action. It gives it a pleasant and cheerful effect which is not noticed in air free from ozone, it stimulates the appetite and produces sound sleep. Its action has been compared with the effect of moderate physical exercises upon the general condition of body and mind. Physical examinations of people working in places which are supplied with poor air

Fig. 8.

have disclosed a decided gain in weight and chest measure after ozonizing their air supply for some weeks.

Ozone is now considered a necessary constituent of good atmospheric air. It is well known that air in cities and in all well populated places is depleted of or entirely free from ozone, owing to the abundance of ozidizable organic matter in such districts. The absence of such floating matter in the open country and especially in the mountains and on the sea is held accountable for the presence of ozone and for the general healthiness at such places.

The question how to improve the air in cities and in closed places where people congregate is a problem which is just now receiving some serious attention for the reason that by far the largest percentage of deaths among the adults in cities is due to diseases resulting from bad air. Perhaps the greatest destination of ozonizers is in the field of improving general air conditions, for the powerful oxidizing properties of ozone can be put to a particularly practical use for purifying and deodorizing air. Indeed, it has been found that foul gases, organic matter floating in the air, offensive odors and everything else which is commonly called air sewage is thoroughly oxydized and destroyed by ozone. Ozone in high concentration will kill any germ known to science; in concentration for breathing purposes its action is different. It is well known that this matter which we have defined as air sewage is a specially attractive ground for bacteria, miasmata and other animal and plant life of the lowest order, which thrive in cities and congested districts. In such small concentrations as ozone is employed in ventilation its beneficial action is probably its destruction of organic purposes, it is usually unnecessary to employ artificial matter in the air rather than the direct destruction of bacteria, which has sometimes been accredited to it. It has not been proven that ozone, when diluted to the extent of one part in one million parts of air, can act directly as a bactericide, but it is an established fact that even in such dilutions it acts as a deodorizer and destroyer of the food and favorite surroundings of the bacteria, thus depriving them of the conditions favorable to their propagation. So energetic is the action of ozone on such undesirable matter that the presence in the air of ozone can be taken as indication of the purity of the air and its freedom from air sewage.

Ozonizers made specially for ventilating purposes are now on the market and are made either of portable or stationary type. There are several systems manufactured in this country and in Europe, the latest one on the domestic market being shown in Figs. 8 and 9. It is made either for alternating or direct current and in various sizes to suit the requirements of the air space to be taken care of, and is portable, self-contained and adjustable. The general plan of these machines is to draw in the air to be ozonized and subject it to electrical stresses by passing it through an air gap in which a silent electric discharge takes place, and then discharge it immediately to the outside air.

The cost of operation of such ozonizers is, as a rule, very low. For example, for the apparatus shown in

Fig. 9.

cuts, the consumption of electric current is about 65 watts for circulating and ozonizing 10,000 to 15,000 cubic feet of air per hour. The concentration is, of course, very small and does not greatly exceed that found in the best outdoor atmosphere. It should be mentioned here that a common mistake made in the installation of ozonizers for ventilating purposes is that too high a concentration of ozone for breathing purposes is produced. An excess of ozone in the air is un-

pleasant to many people and, while it cannot be considered dangerous, still there is a possibility of producing temporary discomfort. The concentration best adapted for breathing purposes has been a subject of much discussion, and it has been variously given as from .0001 to .5 gram per cubic meter air. For direct breathing a concentration of .5 gram is altogether too high and would be extremely unpleasant even for only a few minutes. The figure that has been best agreed upon is a concentration just a trifle higher than the natural concentration in the atmospheric air, say about 2 parts ozone in 1,000,000 parts of air, or about .0012 gram ozone per cubic meter air. A popular instruction for the use of such ozonizers is that there should be enough ozone in the air that its odor is just perceivable at all times. Ozonizers giving higher concentrations than .01 gram cannot be considered safe, and in using such apparatus particular pains must be taken to have the concentration properly reduced by diffusion.

While one is inclined to regard these ozonizers skeptically at first, still their benefits in every day life have been proven and demonstrated in many cases by

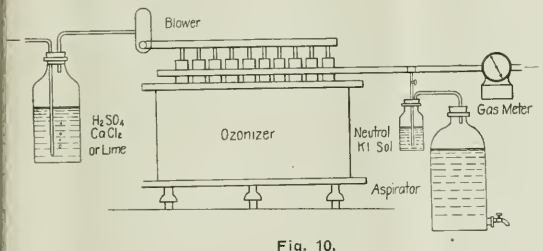


Fig. 10.

medical authorities. As a general means for improving the air and as a deodorizer, ozonized air has found no rival and is bound to come into very general use. Numerous houses, hotels, schools, theaters, and restaurants, and especially abroad, the leading establishments of this kind have been equipped with them, and the reports on their effectiveness are generally very gratifying.

Miscellaneous Applications.—The industrial applications other than for water purification and ventilation are manifold. What I have said about manufacture, ventilation, and water purification will give you a fair idea of the possibilities along different lines, and I have perhaps treated these two applications at greater length than their relation to chemical engineering demands.

For reasons previously explained the use of ozone as an oxidizing agent in purely chemical industries has not yet been recognized to any great extent. Since, however, it has been possible to obtain concentrations up to 30 grams of ozone per cubic meter of air, which corresponds to 2 per cent by volume by means of a comparatively simple apparatus many possibilities present themselves of using ozonized air for oxidization processes, especially in cases where it is desirable that no foreign element be introduced into the reaction.

By virtue of its gaseous condition and its powerful oxidizing qualities, ozone is an ideal gas for sterilizing and disinfecting purposes. Like all strong oxidizers, ozone is destructive to animal and vegetable life of the lowest order, while to animals of higher order and to human beings it is comparatively harmless. There are several installations that are being experimented with in order to test the efficiency of ozone as a disinfectant, one being, for example, at the quarantine station at New York and another one at the Pittsburgh Homeopathic Hospital. Judging from the results obtained in sterilizing rooms, bandages, laundry and surgical instruments in hospitals, it is believed that ozone will ultimately supplant formaldehyde in disinfecting rooms and buildings. The concentration used for disinfecting and sterilizing purposes is, of course, rather high and should not be less than 5 grams and preferably as high as 10 grams per cubic meter air. The sterilization of sewage is a problem which we will be confronted with in the near future in order to avoid the increasing pollution of our rivers and lakes and will be a very fruitful subject for ozone some day and one in which it will have to show its full worth. Very considerable concentrations are required for this purpose and 10 to 20 grams per cubic meter air will be none too high.

The uses of ozonized air in medicine are many, but it is not within the scope of this paper to discuss them. Let it be mentioned that it has been used successfully for inhalation in cases of anemia, nervousness, insomnia, and pulmonary diseases, or for local application in the treatment of skin diseases, cancerous growths, in obstetrics, etc.

One of the largest fields for ozone in the future times is the preservation of food products. Experiments have shown that milk, cream, and butter can be completely sterilized and therefore kept from fermentation and souring for a considerable period of time; eggs, when stored in an atmosphere of ozonized air, will keep for months without apparent change; the effect on fruit is still more striking, as ozone prevents the moulding, which starts on the outside of the skin. In storing meat products it has been found that refrigeration is greatly helped if the air in the storage rooms is ozonized, and that the temperature of the refrigerating room or chamber can be considerably higher in the presence of ozonized air than under ordinary conditions. As a preservative, ozone is also destined to meet with considerable use, supplanting drugs, sugar, and sterilization by heat.

The apparatus necessary in the applications of ozone is very simple. It is illustrated in Fig. 10 and consists of the drying bottle or tank, containing sulphuric acid, calcium chloride, or lime; the fan, blower, or air pump necessary to circulate the air through the ozonizer and the ozonizer proper, containing the step up transformer. For experimental purposes it is usual to have a

rough testing outfit in connection with the apparatus, consisting of an absorbing bottle for the potassium iodide solution, an aspirator to draw in from the main tube and measure the volume of air passing through the absorbing solution, and a gas meter in the main line, by means of which the total volume of air ozonized can be measured.

Considerable success has been achieved by the use of ozonized air in order to prevent the growth of parasites, as, for example, in the storage of flour and flour products, to prevent moulding. It has also been applied in many cases, especially in England and Belgium, to the fermenting cellars of breweries, where it prevents the growth of parasites and still has no retarding effect on the fermenting process. The number of living bacteria in those cellars is said to be thereby also greatly reduced, and it is generally found that those which are not directly killed are not capable of reproduction.

Concentration of about .5 gram ozone per cubic meter air is usually adapted for this purpose. Besides this, a number of breweries have adopted the ozone system for the purification of their water supply.

In the case of the manufacture of wines and liquors ozone is being used to a large extent in France for the purpose of destroying the empyreumatical odor and oxidizing the fusel oils in products which have not been sufficiently aged. The action of ozone in this case is said to be identical to the action of ageing and it is reported that wines and liquors are produced in France in from three to twelve months which cannot be distinguished from similar products which have been ageing for from two to ten years. Ozonized air is also largely used for sterilizing casks and other implements used by producers of wines and liquors.

The bleaching and deodorizing properties of ozone have been recognized early, and are now being utilized to a considerable extent in the case of fats, greases, and oils of mineral, vegetable, and animal origin. Vegetable oils, for example, are not only bleached and discolored, but also thickened, and in the case of animal products, like tallow, grease and fats, ozone has been found a valuable means of improving appearance and quality. Rancid and other offensive odors can be entirely removed, and it is possible in this way to considerably reduce the amount of waste in such materials.

In the case of sugars, as well as flour and starch, ozonized air has been found to accomplish bleaching very satisfactorily. Its bleaching effect is superior to even that of chlorine and is all the more striking, as it not only bleaches but destroys diseased parts and kills parasites which feed upon such products. There are hundreds of other applications of ozone in bleaching, such as, for example, delicate processes like bleaching of ostrich feathers and fine fabrics. In ordinary laundry work ozone surpasses the effect of bleaching chemicals and has the additional advantage of sterilizing the fabrics without injuring the strength and flexibility of the fiber, such as the bleaching agents generally used for this purpose do. The bleaching of wood pulp is also one of the future fields for ozone. As to the concentration of ozonized air which is employed for bleaching, it is evident that it should be as high as possible, and an average of 8 grams per cubic meter air is none too high for this purpose.

There are a number of purely chemical uses for ozone, and it is safe to predict that as an oxidizing agent it will come into much more general use in chemical manufacturing and research work than it is at present. As an example I remind you of the use of ozone in the production of artificial camphor, in the synthesis of rubber, and the large field it will have in the future in the manufacture of perfumes.

The metallurgical industry has started to make quite an extensive use of ozone in the cyanide process of extracting gold, and it is claimed that the yield has been increased from 60 per cent to over 90 per cent by means of ozonized air.

A field for ozone which has not as yet been exploited, but which is bound to become important in the future, is the sterilization of the water for refrigeration. Ice made from water which has previously been purified with ozone is perfectly clear and sterile, and will ultimately fill a long felt want in this direction.

As a deodorizer there is no substance which can anywhere equal ozone, and it is possible by means of it to remove in an incredibly short time offensive odors in storage rooms, glue and leather factories, and in other establishments noted for their disagreeable odors.

The outline which I have given you of the accomplishments and possibilities in this new field should serve the purpose of calling your attention to and awakening your interest in a product which for general usefulness is surpassed by very few of the thousands of substances known to chemistry. There is no special branch of the chemical industry where ozone cannot in some manner or other fill a want, and I believe that there are few, if any, members of this institute present who will not find it to the interest of the industry they represent to further investigate the subject.

The Pan-American Congress, recently in session at Buenos Ayres, adopted a resolution for the adoption of the sanitary convention, regarding contagious diseases, drawn up at the Sanitary Conference of American Republics, at Washington, in 1905, supplementing it with an additional paragraph to the effect that the declaration of the cessation of an epidemic, required before quarantine is removed, be made to the satisfaction of both the country of destination and the country of sailing of steamers subject to quarantine. The Congress further adopted resolutions favoring the exchange of professors from the universities of the various American Republics to discuss in their lectures American questions.

MODERN DEVELOPMENTS OF THE GAS INDUSTRY.*

By WM. DAVIDSON, Ph.D., D.SC., F. I. C.

On the 9th of June, 1810, the bill promoting the incorporation of the Gas Light & Coke Co. of London, England, the first public gas undertaking, received royal assent. The actual inventor of gas lighting, William Murdoch, was an engineer in the employment of the famous firm of Boulton & Watt, Soho, Birmingham, England. Whilst in their service he found time to bring to a successful issue experiments on the distillation of coal which he had begun in his youth. In 1792 he installed gas lighting in his house at Redruth. In 1803 part of the Soho works was lighted by gas, but it was not till 1807 that a distinct advance was made when the large cotton mill of Messrs. Phillips and Lee, Manchester, was fitted with a complete gas installation. Progress was naturally very slow at first. Presently other pioneers, notably Clegg and Winsor, entered the field. The latter was the principal mover in the formation of the first gas company. During the past half century the development has been very remarkable, and today the proportions of the industry have attained huge dimensions.

A rough estimate of the annual production of gas, coke, and residuals by the gas-works of the United Kingdom is given below:

Materials used—	Quantity.	Value, £.
Coal for gas-making, tons..	16,000,000	10,000,000
Oil for gas-making, gals...	60,000,000	700,000
Oxide for purification, tons.	70,000	80,000
Lime for purification.....	?	?
Products sold—		
Gas, cu. ft.	190,000,000,000	24,000,000
Coke, breeze and dust, tons	8,000,000	5,000,000
Ammonia as sulphate, tons.	165,000	1,800,000
Tar (coal & C.W. gas), tons	900,000	900,000
Sulphur in spent oxide, tons	70,000	100,000
Cyanogen as sodium prussate, tons	3,000	90,000
Spent lime.....	?	Practically nil
Retort carbon, tons.....	5,000	7,500

Approximately 11 per cent. of the gas made is carburetted water gas.

On the continent, the magnitude of the gas industry, relative to the population, is much smaller. The total quantity of coal carbonized for gas in Germany is only 5,500,000 tons per annum, 25 per cent of which comes from England. Coal in Germany costs on an average about 20s., whilst coke is sold at 25s. a ton.

In the United States carburetted water gas bulks more largely in the public supply than coal gas. I have not been able to obtain definite estimates of the gas-making materials used in that country.

During the eighties and nineties the rate of increase in the output of gas in this country was seven or eight times the rate of increase in the population. Naturally this extraordinary development could not be maintained for very many years, and so it is not surprising that the last decade has witnessed a considerable slacking in the demand for town gas.

I have compiled Table I from "Field's Analysis," the gas outputs for 24 of the largest gas undertakings in the United Kingdom for the years 1888, 1898 and 1908, together with the decennial percentage increments for the two intervals in question.

The metropolitan companies, it will be observed, are making less rapid progress than the provincial undertakings, whilst London suburban companies show an abnormally high rate of increase. This is only what might have been expected. It is gratifying from the manufacturer's point of view that in spite of economies in the consumption of gas for lighting purposes, the ever-growing competition of electricity for the supply of light and power, and the introduction of producer-gas plants in large factories, the average rate of increase in the output of gas is still more than double the rate of increase of the population.

GAS OUTPUT OF 24 OF THE LARGEST UNDERTAKINGS OF THE UNITED KINGDOM.

Name.	Millions of cubic feet.			Decennial percentage increase.	
	1888.	1898.	1908.	1888-1898.	1898-1908.
Gas, Light & Coke Co.	18,610	22,400	23,740	20.4	6.0
So. Metropolitan Co..	5,890	9,825	12,700	66.8	30.2
Birmingham Corporation.....	3,722	5,531	7,328	48.6	32.5
Glasgow Corporation..	2,705	5,355	7,034	98.0	31.3
Manchester " ..	3,046	4,258	5,779	36.5	39.0
Commercial Co.	1,989	2,614	3,369	31.4	28.9
Sheffield Co.	1,649	2,424	3,474	47.0	43.3
Newcastle-on-Tyne Co.	1,668	2,519	3,350	51.0	33.0
Brentford Co.	1,031	1,658	2,866	60.8	72.9
Bristol Co.	1,348	1,798	2,684	33.4	49.2
Nottingham C'rporat'n	1,405	1,697	2,109	20.8	24.2
Leicester Corporation.	900	1,451	2,062	61.2	42.1
West Ham Co.	579	1,009	1,903	74.2	88.6
Salford Corporation..	843	1,346	1,716	59.7	27.5
Dublin Corporation...	1,233	1,447	1,555	17.4	7.5
Tottenham Co.	279	525	1,495	87.5	185.9
Oldham Corporation..	810	1,094	1,471	35.0	34.5
South Suburban Co...	747	1,121	1,293	50.0	15.3
Portsea Co.	565	764	1,384	35.2	81.2
Croydon Co.	389	673	1,293	73.0	92.1
Brighton Co.	821	1,027	1,261	25.1	22.8
Wandsworth Co.	311	631	1,105	102.9	75.1
Plymouth Co.	508	836	1,096	64.6	31.1
Bolton Corporation ...	629	885	1,022	40.7	15.5
Totals	51677	72,786	93,179	40.8	28.0
				Average.	

*From the Journal of the Society of Chemical Industry.

If we analyze the figures for individual years we find that the weather is the most important factor to be considered as affecting the consumption. In particular the presence or absence of fogs has a marked effect. Now that a very considerable proportion of town gas is used for industrial purposes, we also find a reflection of the state of trade in the annual records of the gas-works. Thus it may happen that a curve representing the annual output of gas for a given town may be somewhat irregular and may even exhibit an occasional fall. The incomes from the different by-products are subject to the market fluctuations, which are sometimes rapid and unforeseen. The cost of coal and oil also varies from time to time, and thus the selling price of gas is subject to frequent alteration. The case of Birmingham will serve to illustrate these fluctuations.

The following figures, Table II, are compiled from "Field's Analysis" for the year 1908, for 27 gas undertakings representing 50 per cent. of the total gas industry of the United Kingdom. It permits of an interesting comparison of materials carbonized, capital employed, price of gas, quality of gas prescribed and supplied, and the burner used for testing purposes.

Gas Lighting.—The introduction of the upright incandescent mantle by Auer von Welsbach about the year 1886 for a time threatened to have a prejudicial effect on the development of coal gas just as the modern metallic filament lamp has given electricity undertakings cause for alarm. In the one case the duty of 1 cu. ft. of gas was increased from 3 to 20 candles, in the other the efficiency as compared with the carbon filament lamp has been trebled. The Welsbach mantle, however, has proved a blessing to the gas industry in the later days of competition. The last decade has seen the introduction of the inverted mantle which gives a higher efficiency than the upright, is easier to handle, and lends itself to more artistic arrangement of the fittings. Inverted burners are now much used in small units of 10 to 30 candles, a further economy in the lighting of small rooms being thus effected.

With gas at 2s. 6d. per 1,000 cu. ft. giving an efficiency of 20 candles per cu. ft., 1,000 candle-hours cost, for gas only, 1.50d., whilst with electricity at 3½d. per unit Osram lamps giving an efficiency of 0.90 candle per watt the same amount of light costs, for electricity only, 3.90d.

Much ingenuity has been expended in the improvement of burners and mantles, and new devices are continually appearing on the market. We would seem to be within measurable distance of the ideal burner, which can be turned on or extinguished by tap or switch without the aid of by-pass. Incandescent gas lighting can only be rendered reliable, however, by attention to the burners, maintenance of a uniform gas-pressure of two to three inches (water gauge) and fairly uniform calorific value. Flat flame burners, on the other hand, do not require a greater pressure than two or three-tenths of an inch. Some gas companies now undertake maintenance of the burners of consumers in the belief that a little attention of this kind is more appreciated than a small reduction in the price of gas. The increase of pressure in the gas mains has not proved to be a cause for alarm so far as leakage is concerned.

Street lighting and the illumination of large rooms is accomplished most effectively by high-pressure gas consumed in burners of special construction fitted with strong mantles. There has been considerable development along this line during the last five years. This would have been much greater had it not been for the additional expense entailed by the erection of compressing plants for the different installations. When high-pressure gas is supplied from the gas works in special mains, such as are being laid in Birmingham and some other towns, no extra outlay on the consumer's part will be necessary, and he will thus be able to derive immediate benefit, whilst the streets will have the full advantage.

The best type of high-pressure burner has an efficiency of 60 candles per cubic foot, that is, three times as much as the ordinary burner. The pressure required is about 50 ins. (water gauge) or 2 lbs. per sq. in. The cost for gas only at 2s. per 1,000 cu. ft. (assuming a lower price for gas in bulk), is thus only 0.40 of a penny per 1,000 candle-hours. To equal this figure electricity must be supplied with flame arcs (efficiency, three candles per watt) at 1¼d. per unit. So successful has high-pressure gas proved itself for street lighting that electric arc lighting already installed has had, in a large measure, to give way to it. Berlin, which is looked upon as the foremost city in Europe in the matter of street illumination, has decided in favor of the inverted high-pressure gas lamp, and it would appear that London is going to follow suit judging from the fact that a deputation of the Streets Committee, after visiting and carefully examining the systems of lighting in some of the principal continental cities, recommended in July last "that high-pressure incandescent gas lamps with inverted burners should be adopted as the illuminant; but where gas is impracticable, electricity with open arc and flame arc lamps should be installed." I think this must be looked upon as a great victory for gas lighting.

Gas Heating.—Hitherto the gas fire has not been regarded as an economical means of heating a room, however convenient it may be, but owing to defects of construction in older types it had acquired somewhat of an evil reputation. Within the last year or two, however, great improvements have been made.

It has been generally recognized that radiation must play an important part in the heating of a room, and the capacious bed of "fuel" has been abandoned in favor of single-row tubular pyramid "fuel." An elaborate piece of research on a gas fire of the modern type referred to has been carried out at Leeds University. The results were published in June last, and the conclusions are as follows: (1.) The total radi-

ation from an open gas fire is about 32 per cent, and this is unaffected by the amount of ventilation through the room. (2.) No carbon monoxide escapes under ordinary conditions into the room, and very little is ever found in the flue. (3.) About 30 per cent of the heat generated in the stove passes directly into the flue. This figure varies with the volume of air passing through the stove flue. (4.) There is no necessity for products of combustion to enter the room and cause discomfort. (5.) Reflectors may be usefully employed to produce a sensible increase of radiation into the region where it is most wanted.

A thermal efficiency of 70 per cent (half by radiation, half by convection) is probably more than three times as much as that of a good coal fire. Gas of a net calorific value of 540 B. T. U. per cubic foot at 2s. 6d. per 1,000 cu. ft. gives 18,000 heat units for a penny, whereas coal of a calorific value equal to 14,000 heat units per lb. at 18s. 8d. per ton (1d. for 19 lbs.), gives 140,000 units, or eight times as much. On this basis a gas fire is more than twice as costly as a coal fire. Nevertheless, just as the special advantages of electric power under certain circumstances outweigh the doubling or trebling of the cost per brake horsepower as compared with gas or steam, so the convenience, cleanliness and labor-saving of the gas fire recommend its use to the average householder. With reductions in the price of gas and further improvements in the appliances, it is not too much to hope that gas fires will be more generally used in the future. From the point of view of smoke abatement this is a consummation devoutly to be wished.

Mr. Onslow, Superintendent of the Gas Factory, Royal Arsenal, Woolwich, a pioneer of high-pressure gas lighting, has done much to bring into prominence the utility of high-pressure gas for rapid heating and high temperature. The advantages of pressure gas over the ordinary blowpipe lie in the simplicity of the

TABLE II.

Name.	Coal Carbonized. Thous. Tons.	Oil for C. W. Gas. Thous. Gals.	Capital Employed. Thous. £	Sale Price of Gas. Av. Pence per 1,000 cu. ft.	Illuminating Power of Gas. Standard. Candles.	Illuminating Power of Gas. Supplied. Candles.
Gas, Light and Coke....	1,710	14,167	13,856	32.9	16¶	16.9¶
South Metropolitan	1,183	.....	5,519	26.6	14¶	16.6¶
Birmingham*	572	2,579	2,909	23.9	15[5]	16.2[5]
Glasgow†	739	.....	2,360	27.7	16[7]	18.5[7]
Manchester‡	421	2,709	2,741	27.4	..	17.5¶
Commercial	202	2,525	1,426	29.2	14¶	15.1¶
Sheffield	327	.....	973	15.0	16½[5]	17.4[5]
Leeds‡	180	665	1,871	24.8	14[5]	15.5[5]
Newcastle	301	64	2,214	21.4	15½[5]	16.2[5]
Brentford	182	2,609	1,118	32.6	14[6]	15.0[6]
Bristol	280	.....	1,411	23.3	14½[5]	16.0[5]
Nottingham‡	194	65	1,156	30.3	12[6]	16.3[5]
Edinburgh and Leith¶..	176	500	1,633	34.4	20[7]	20.4[7]
Bradford	204	.....	1,188	23.4	15[5]	17.0[5]
Leicester	180	.....	1,309	28.2	14[5]	15.8[5]
West Ham	101	1,678	1,134	31.9	14¶	14.7¶
Salford‡	167	.....	942	29.5	18[6]	19.3[6]
Dublin	77	3,430	1,248	42.5	16[7]	16.5[7]
Tottenham	83	1,268	617	29.0	14¶	15.5¶
Oldham‡	110	368	607	23.6	14[6]	20.3¶
South Suburban	130	.....	629	30.4	14¶	15.2¶
Portsea	113	897	473	31.1	14[5]	14.2[5]
Croydon	82	1,031	691	33.2	14[7]	14.6[7]
Brighton	71	1,190	711	36.1	15[5]	15.5[5]
Wandsworth	71	822	361	23.8	14[7]	14.9[7]
Plymouth‡	55	1,133	400	21.7	14[6]	14.5[5]
Bolton‡	100	.....	800	29.5	16[7]	18.2[7]
Totals	8,020	37,709	50,297	28.3 (Av.)		

* Year ending March 31, 1909. † Year ending May 31, 1908. ‡ Year ending March 31, 1908. ¶ Year ending May 15, 1908. [7] By flat flame burner. [5] By London Argand burner, No. 1. [6] By 15-hole Argand burner. ¶ By Metropolitan Argand burner, No. 2.

fittings and the case with which the pressure can be altered at will.

The furnaces now used with high-pressure gas for annealing shells, etc., in the arsenal are of the simplest construction, and work with coal gas at 2½-lb. pressure. Temperature of 1600° C. can be attained without much difficulty in small furnaces and thus most metals can be melted. There is reason for believing there will be important developments in this branch of the industry before long.

Gas for Cooking.—In most well-equipped households the gas cooker is regarded as a necessary adjunct of the kitchen. The fitting of a thermometer through the side of the oven, not a usual practice, but one to be recommended—and the use of a quadrant or slow movement tap, render it easy to regulate the oven temperature to a nicety without opening the door, thus ensuring complete success every time—a great consideration with both manufacturer and consumer. Attempts to effect economy by preheating the air required for combustion by means of the waste products have hitherto proved only partially successful. Stoves fitted with appliances for hot water circulation are now on the market.

Some years ago slot or prepayment meters for both lighting and cooking were introduced. In this class of business it is the usual practice to supply meter and fittings free, but to charge the gas at a higher rate. In many towns prepayment consumers are in the majority.

The system has been a powerful agent in popularizing gas lighting and cooking amongst the working classes.

Gas for Motive Power.—Some 30 years ago the indicated thermal efficiency of the best gas engines was only 16 per cent; to-day it is 37. To show the position of gas as regards cost of motive power the following estimates of the cost of a brake horsepower-hour, and the data on which they are based, for steam, gas, and electricity, may be useful:

	Thermal Efficiency. Per cent.		Cost per B. H. P. hour. d.
Steam	6	Fuel, 14,000 B. T. U.'s per lb., at 7s. 6d. per ton	0.16
Gas	30	Gas, 540 B. T. U.'s per cu. ft., at 1s. 8d. per 1,000 cu. ft.....	0.31
Electricity ...	86	¾d. per unit.....	0.65

The above figures only include fuel, solid or gaseous, and electric energy. Labor costs are not reckoned. The fuel required with a suction gas plant is said to work out at only one-tenth of a penny per B. H. P. hour, but in this case the cost of gas manufacture must be added. Without entering into a discussion of the relative merits of different sources of motive power, suffice to say that the perfecting of the gas engine has greatly stimulated the demand for town gas for power purposes in recent years.

So multifarious are the applications of gas that gas supply has become quite a science in itself, apart from gas manufacture. This has been recognized by the City and Guilds of London Institute, whose examination papers are now set year by year since 1908 in gas supply as well as in gas engineering.

Quality of Gas.—Throughout the country the proportion of gas sent out during daylight hours has continued to increase in a satisfactory manner. To-day not a few gas works boast of a day load exceeding 50 per cent of the total, and as only a small proportion of the nightly output is consumed in flat flame burners one may well ask the question: "What is the utility of the test of illuminating power in such cases?" Gas engineers are in the habit of complaining of the injustice of the tests and restrictions imposed on town gas. Some have expressed the view that gas should be as untrammeled in this respect as electricity. This opinion represents an extreme. You will find the other in the words of Prof. H. E. Armstrong, quoted from his presidential address delivered to the Chemical Section of the British Association at Winnipeg last August. Speaking of the gas industry he said: "On the engineering side it had been carried to a high pitch of perfection, but on the chemical side it had ever fallen, year after year, to a lower state. The quality of coal gas was such, especially since the withdrawal of the sulphur clauses from Acts of Parliament by which the industry was regulated, that gas was almost unusable. Had not chemists entirely unconnected with the gas industry vastly improved the methods of burning it, gas would long since have fallen into disuse."

Let us look at this question for a moment. The very rich coal gas of 30 years ago is no longer required. In those times it was not practicable to make anything but rich gas because of the low temperatures of carbonization that were available. There is no disputing the assertion, however, that town gas has been on the down grade for some years, in respect to both illuminating power and calorific value, which to a certain extent go hand in hand. The metropolis has always been looked to for a lead in these matters. Gas referees were established in London by the Act of 1868. At the same time Sugg's No. 1 London Argand burner was adopted for testing the gas for candlepower. The gas was burnt at the rate of 5 cu. ft. an hour on a bar-photometer and tested against the standard given by two candles. This method continued in use in London until 1898 when the table photometer and ten-candle pentane standard were introduced to give greater refinement in testing. The gas was now not consumed at the rate of 5 cu ft. an hour, but at a variable rate so as to give a light equal to 16 candles. The sulphur clauses were abolished by the London Gas Act of 1905, and the ammonia tests were given up. Previously the limit to sulphur other than in the form of sulphuretted hydrogen had been 17 grains per 100 cu. ft. in summer, 22

in winter; the limit for ammonia being 4 grains per 100 cu. ft. At the same time the No. 1 Argand burner, which at the time of its inception was supposed to be capable of obtaining the highest possible duty from the gas, was discarded in favor of a superior contrivance, the Metropolitan Argand burner, No. 2, which chiefly by virtue of an air damper, gets about 10 per cent better value out of 16-candle coal gas, and still more out of lower-grade gas or mixed gas. The South Metropolitan Co. and the Commercial Co. received the further privilege of a reduction in standard from 16 to 14 candles. Testing for calorific value was inaugurated, but no restriction was imposed. Quite recently the Gas Light & Coke Co. obtained parliamentary sanction for the absorption of the West Ham Co. and a reduction in standard from 16 to 14 candles as tested by the new burner. The gas company did not get things all its own way, however, and an additional restriction in the form of a calorific value test was imposed. The gas undertaking is now bound to supply town gas of a calorific value not less than 490 British thermal units per cubic foot, net, but will only be penalized when the figure falls below 446½. Most gas works, I take it, would gladly submit to these dual tests in preference to their present exacting illuminating power standard. Table II gives one some idea of the variety of methods in present use for ascertaining candlepower.

In addition to those mentioned there are several types of flat flame and 15-hole Argand burners in use. The difference between two tests with different burners may be as much as six candles. Differences of two candles may be obtained by artificially altering the atmospheric conditions of a badly constructed photometer-room. It is no wonder, then, that the relegation of the illuminating power test to a subsidiary position will be welcomed by both engineer and chemist.

Tests for sulphuretted hydrogen and ammonia do not intimidate the gas manufacturer. In these days of perfected mechanical appliances and methods, the escape of sulphuretted hydrogen into the town mains is a very rare occurrence; ammonia, on the other hand, is too valuable to lose.

One of the questions of the hour in the gas industry is: "What quality of gas is called for?" Regard must of course be had to modern conditions of high carbonizing temperatures, vertical retorts, chamber-ovens, and other improved gas-making plant, and to the fact that high candlepower as tested by flat-flame or Argand burner is no longer a necessity. A conference of 40 German gas chemists answered the question in May last as follows:

(1.) A standard calorific value of 544 B. T. U. per cubic foot, gross value, say 490 net. (This is the standard observed by the Berlin municipal gas undertaking, it may be remarked.) The calorific value, they further state, should be as uniform as possible, and should not fall below 524 gross, or say 472 net. (2.) Tests of illuminating power are superfluous. (3.) A proportion of 25 per cent of carbon monoxide is permissible in mixed gas. (4.) The gas must always be completely purified from sulphuretted hydrogen, but seeing there is at present no process which can be applied on a practical scale for the removal of other sulphur compounds, which exist only in minute quantities in the purified gas as usually supplied, no limit can be fixed for this. (5.) Restrictions of the amounts of ammonia, cyanogen, naphthalene, carbon dioxide, oxygen, nitrogen, and of the specific gravity are unnecessary.

I think I should be giving expression to the opinion of gas chemists in this country by saying we agree with all the above conditions but No. 2. In the use of town gas a luminous flat or round flame is sometimes absolutely necessary, and as the manufacture of a non-luminous gas of the required calorific value is not an impossibility, it is advisable to stipulate an easy standard of, say, 12 candles with the No. 2 Argand burner. By the way, this burner is not the very best obtainable. The Grafton burner of similar type is slightly better. Either will suit the purpose, however. The volume percentages of the different non-essential ingredients in gas of average quality, as now generally supplied, not purified by lime, are as follows:

Carbon dioxide, 2 per cent; nitrogen, 2 to 16 per cent; oxygen, 0.6 per cent; naphthalene, 0.001 per cent; hydrocyanic acid, 0.03 per cent; carbon bisulphide, 0.02 per cent.

Gas Manufacture.—Under no real obligation to produce gas of high candlepower, and with strong competition to face on all sides, the gas engineer has set himself to reduce costs of gas manufacture by every means in his power. The various methods that have been adopted to this end may be briefly reviewed:

1. Working with smaller retort charges or lengthening the period of distillation gives greater yield of gas per ton of coal, but labor costs increase and this method is not to be recommended.

2. A higher temperature of distillation affords a ready means of increasing the output of gas, and has been resorted to quite generally throughout the country. Iron retorts were discarded in favor of clay retorts many years ago; while direct firing is now to be found only in some small works.

Heating by means of producer gas generated under the retorts and the use of regenerative effect instituted by Siemens came into general use twenty years ago. In this way not only was the yield of gas increased but the consumption of fuel was greatly diminished. Coal which formerly produced 9,500 cu. ft. per ton gave 11,000 or more.

The fuel used per 100 lbs. of coal carbonized with direct fires is about 25 lbs., with generators 18. There were some disadvantages, however. Capital and maintenance charges were largely increased. Naphthalene, a high temperature product of destructive dis-

tillation, made its presence felt, as there were now insufficient heavy hydrocarbon vapors present to hold this substance in solution when condensation took place. Naphthalene trouble kept the distribution department at its wits end for some years. The symptoms were numerous blockages in the small pipes or services and the stoppage of the gas supply. These occurred principally in the summer and autumn. In aggravated cases, mains on the works were also blocked. The fact that stoppages occurred more frequently in July, August and September is accounted for by there being a wider range of temperature during these months as between day and night. Gas saturated or nearly saturated with naphthalene at summer heat was sent out during the day and deposited its naphthalene as the pipes cooled down in the chilly evening. The amount of naphthalene in gas saturated at 60° F. does not exceed 0.008 per cent by volume, whilst the average amount present in town gas is less than one-sixth of this, and is carried forward to the burner to be consumed. Naphthalene, however, forms very voluminous crystals; as small a quantity as three grains may occupy a volume of one cubic inch.

The stoppages were detrimental in three ways. They entailed a great deal of expense in removal; they curtailed the consumption of gas; and they gave gas a bad name. After years of suffering two or three reliable cures were at length discovered. One consisted in washing the gas in the works with a heavy oil—creosote or anthracene oil—so as to remove the great bulk of the naphthalene, and another in adding the vapors of suitable oils to the gas without removing any naphthalene in the works, the oil only taking effect when condensation commenced. The former method depreciates the quality of the gas to a series extent unless 4 or 5 per cent of benzol be previously added to the oil.

A combination of the two methods, whereby the gas is washed so as to cause the removal of a small portion of the naphthalene and rendered sufficiently rich in the vapors of oils of the necessary vapor tension, is probably the most economical and reliable way of dealing with the naphthalene difficulty. The oil most suitable for vaporizing has been found to be crude naphtha, distilling to the extent of 90 per cent between 140° and 200° C. Less expensive oils such as light kerosene, first runnings from the distillation of carburetted water gas tar, or even carburetted water gas tar itself, have been found more or less effective. With a little attention, a complete cure can be effected and maintained at an expense which is trifling when one takes into account the enriching value of the oil added.

Some idea of the extent of the trouble and the completeness of the cure may be gathered from the figures for Birmingham, where the curative process was begun in 1906:

NAPHTHALENE COMPLAINTS.

1904	16,646
1905	22,748
1906	530
1907	95
1908	46

Another difficulty which became intensified was "stopped pipes." This trouble is rendered the more acute the higher the temperature, the older the coal, that is the less volatile matter it contains, and the lighter the charge. It entails loss of gas and considerable labor costs. It has been overcome by increasing the size of the ascension pipes, by a proper system of augering the same, and by introducing a small quantity of steam or a drip of water.

As very high temperatures were attained the defects of fireclay material also became a source of trouble, a portion of the retort setting not infrequently giving way. Greater attention has therefore had to be given to the quality of fireclay goods. Steps have already been taken by those interested in the fireclay industry with a view to improving and standardizing refractory material for use on gas works.

3. A combination of large charges with high temperatures represents the acme of perfection of modern methods of carbonization.

Under similar conditions of temperature and exhaust the make of gas per ton is not so great in this case as with smaller charges but the quality is decidedly better. The effect of putting a large charge into the retort is to diminish the free space above the coal and to lessen the degree of degradation of the hydrocarbons to carbon and hydrogen. The carbonizer finds he can use more exhaust to bring the gas down to standard, hence the prevalent erroneous idea that heavy charges give a larger yield of gas per ton of coal. An analysis of the gases will show an increase in nitrogen.

Possessing the advantage of a 14-candle standard with No. 2 Argand burner, some gas engineers have been at a loss to know how to manufacture gas of this low illuminating power with the plant at their disposal. The simplest way of doing it is by "over-pulling," but this can only be done at the expense of the calorific value of the gas. One occasionally hears in these days of abnormally high makes of 12,500 to 13,000 cu. ft. per ton from ordinary coal carbonized in horizontal retorts, and the success is sometimes erroneously attributed to the marvelous working of mechanical devices such as retort-house governors, dry hydraulic main, or steam in the ascension pipe. I think it is much to be deplored that gas engineers have found themselves compelled to resort to dilution of the gas by "over-pulling." The percentage of nitrogen has gone up very considerably in many large towns in England—not in Birmingham, I may say.

In some cases it is as high as 16 per cent. This is one way of making low-grade gas—it is assurely not the best way. The accepted practice in this country is

to carbonize at level gauge, that is, to maintain the gases in the retorts at atmospheric pressure on the average. Working with a retort-house governor and a dry haydraulic main this gives a gas containing 4 to 7 per cent of nitrogen, which might be regarded as permissible—the theoretical amount is always less than 2 per cent. The German gas engineer goes to the other extreme and instead of "over-pulling" maintains an average pressure in the retorts of about one inch (water column). The gas then contains about 3 per cent of nitrogen, but there is undoubtedly considerable loss through leakage into the furnace.

4. New Plant.—Manufacturing costs have been appreciably reduced not only by higher production of gas but also by new machinery. A great deal of mechanical ingenuity has been expended in the construction of stoking appliances. Two of the best known of the older types are the "West" machine working with compressed air and the "Arrol-Foulis" working with hydraulic power. Of the latest machines the "De Brouwer projector," which throws the coal off a revolving belt and the "Fiddes-Aldrige" machine which fills and empties the retort at one stroke are among the most successful. Both the last-named are as a rule electrically driven.

The machine most in demand for modern carbonizing practice is one that can almost completely fill the retort, the discharge being effected by a "pusher."

Inclined retorts were introduced into England in 1865. They are usually set at an angle of 32° and dispense with stoking machinery. There are difficulties in charging them satisfactorily. Much depends on the nature and size of the coal and as a rule they take only the normal charge of 6 to 7 cwts. A few settings of retorts have been set at 45°, at which angle it is possible to work with full charges.

Vertical Retorts.—A great advance in carbonizing has been made by Dr. Bueb of Dessau, who brought out the vertical retorts in 1906. The main advantages of the Dessau system over the horizontal and inclined retorts in common use may be enumerated as follows: 1. Higher yield of gas per ton of coal, and per unit of ground area. 2. Gas is nearly free from naphthalene. 3. The yield of ammonia is considerably increased. 4. The tar is thinner and contains less free carbon. 5. The coke is large and dense. 6. Steam may be admitted with advantage at the end of the carbonization period to make a certain amount of water gas. 7. The work is easier for the men.

There are now over 4,000 Dessau retorts in use on the continent. Some are four meters in height and take charges of 10 cwts. of coal every ten hours.

Others are five meters long and take a corresponding larger charge. An installation of sixty Dessau retorts, the first of its kind in England, has just been completed in Sunderland.

English engineers have not been idle meanwhile. Theirs is the higher ambition to perfect a continuous process of charge and discharge in vertical retorts. This is an ideal system of distillation which will no doubt achieve ultimate success. At present only a few retorts of this type are at work—some on the "Woodall-Duckham" and some on the "Glover-West" system. The mechanical difficulties have been largely overcome, but so far the carbonizing results are somewhat disappointing.

Chamber Ovens.—Attention is now being turned to the adaptation of the large coke oven to gas making. Chamber ovens are already competing with vertical retorts. Here again we have to thank our German friends for the innovation. The original Munich chamber ovens were inclined, but they are also being built horizontally and vertically. The charge in the largest size is about seven tons. Their advantages over vertical retorts are: 1. Still lower carbonizing costs. 2. Superiority of coke and elimination to a great extent of night work. No accurate information is so far available with regard to gas, liquor and tar. It is safe to say that want of uniformity in the gas made must militate against their adoption in small works.

The following is a rough comparison of the carbonizing costs (charging, drawing and firing) per ton of coal for the different systems:

	Pence.
Hand labor	38
Old machinery, horizontals	18
Inclined retorts	12
New machinery, horizontals	8
Verticals	4
Chamber ovens	2

Residuals.—Let us now briefly consider what progress has been made in the production of residuals.

Coke, Breeze and Dust: The sale of coke has been encouraged by paying strict attention to the sizing. It is now the usual practice to screen the coke so as to produce large coke, small coke, one inch breeze, breeze, pea breeze and dust to suit the requirements of different classes of customers. There is a steady sale of considerable quantities of "small coke" for household use. Coke dust formerly sent to the tip is now sold for use in boiler furnaces where special fire-bars and forced draught are used. At some works, particularly in Germany, coke dust is mixed with tar and converted into briquettes which find a ready sale.

In 1907 patents were taken out for the manufacture of what was described as a new smokeless fuel called Coalite. The material is now produced on a fairly large scale by the British Coalite Company at Wednesfield and Plymouth.

This fuel is the product of coal carbonized at a temperature of 1000° F. as against 1800° for ordinary gas coke. In the process of manufacture the gas made per ton of coal is only about 5,000 cubic feet, half of the total volatile matter of the coal remaining in the coke. The tar obtained is about 20 gallons and is of a light nature and particularly rich in paraffins. The yield of ammonia is 70 per cent of that produced

at high temperature. Coalite ignites more readily than ordinary gas coke and burns with more flame, but it is only slightly better in heating efficiency.

In view of its greater efficiency and smokelessness, as compared with coal, coke merits a much larger sale for household purposes than it at present enjoys.

Ammoniacal Liquor: There is little to be said regarding this residual. Synthetic nitrogenous manures, such as nitrolime, have hitherto failed to prejudicially affect the sale of ammonium sulphate. A considerable quantity of gas liquor is now converted into strong ammonia both in this country and on the continent. This is found to be much more remunerative at present prices. Quite a large number of gas works possess a sulphate plant which in its improved modern construction is easily controlled. The extraction of ammonia from crude coal gas in these days of perfected mechanical appliances is very complete indeed. In the final washing with a rotary washer of up-to-date construction one may confidently expect an efficiency of 99 per cent.

Tar: Since the discovery and development of the aniline dyes, coal tar has had an attraction for the young research chemist. The unfortunate fact remains that 30 years ago tar fetched nearly double the price that it does to-day. The cause of the fall in price is the usual one—the supply is greater than the demand. Quotations depend largely on the market for pitch. As a dressing for roads a new use has been found for gas works tar. It is said to preserve the surface of the road from disintegration and suppress the dust nuisance. Its use is accompanied by diminution in the expenditure on road cleansing, watering and maintenance. Carburetted water gas tar is of slightly less value than coal tar. Special use has been found for it in the manufacture of naphthalene solvent. It yields a good kind of pitch which finds a use in the manufacture of special varnishes.

Spent Oxide: One of the troubles in purifying the gas by means of oxide of iron has been "back pressure" caused by the oxide settling down in a compact mass, and thus offering excessive resistance to the passage of the stream. This has been remedied in a large measure by alterations in the design of the grids supporting the material. Various kinds of oxide ore are employed, but they are being displaced quite a large extent by "artificial oxide" prepared from the burnt spent oxide. This material is inactive towards sulphuretted hydrogen immediately after coming from the kilns but after exposure to the action of air and water for a prolonged period and treatment with a little lime and copperas it is able to do its work satisfactorily, especially when lightened by the addition of sawdust or similar material. Nearly all the spent oxide of the gas works is used for the manufacture of sulphuric acid. A small proportion is bought by a few chemical works for the extraction of Prussian blue and sulphocyanide. This is said to be a profitable business only when the oxide contains at least 5 per cent of the former ingredient. Lime for purification has been largely discarded, especially in the south of England.

Cyanogen Extraction: Ten or 12 years ago and occasionally since then prussiate of soda crystals were quoted at 4½ and 5 pence per lb. The price has been dwindling down for some time and during the present year it has stood at 3 pence. At the former figure a handsome profit could be made if the plant was sufficiently large to treat at least two million cubic feet of crude gas per day. At the present time few are bold enough to erect expensive appliances for the sake of cyanogen recovery. In the absence of a cyanogen recovery plant the impurity (only 0.2 per cent by volume of hydrocyanic acid) is removed to the extent of about 80 per cent by the oxide through which it has to pass. Prussiate processes on the Fouls, Davis-Neill, or similar systems are now in operation at seven or eight large gas works in England.

A description of the various processes would carry us too far. Suffice it to say that ferrous hydrate, sulphide, or carbonate mud is the essential ingredient, the base being either ammonia, soda, or lime, or a combination of these. One of the great difficulties experienced has been to find a suitable washer to deal with a heavy sludge. The Holmes brush rotary washer is employed with success when the mud is thin, but troubles ensue when the sludge is inclined to be gritty or thick. The highly ingenious washer patented by Feld in 1906, though not so high in efficiency as one would like, gets over this difficulty very satisfactorily.

It is more profitable to treat the gas before removing the ammonia. On the continent the Bueb prussiate process is very generally employed in the larger works. The method consists simply in running a strong solution of copperas from time to time into a rotary washer. The sludge containing soluble and insoluble prussiate is sold to chemical works.

The British Cyanides Company's patented process of extraction has been in operation at a number of moderate-sized works for some years. In this process sulphur is added to strong ammonia liquor in a suitable washer to form polysulphide, which takes up the hydrocyanic acid to give sulphocyanide. The resultant product is sold in the form of liquor to the chemical works.

Development in Purification.—Carbon bisulphide. Under the old restrictions of the sulphur clauses, lime had to be employed on a large scale. This was sulphide so as to remove the carbon bisulphide as thiocarbonate. At the same time a large proportion of the carbon dioxide present was eliminated. With the repeal of the clauses the use of lime became no longer necessary except where no better means could be found of maintaining the illuminating power. It is possible to gain one "candle" by removing all the carbon dioxide, but all things considered it has generally been found unprofitable to do so. When the sulphur clauses

were enacted the incandescent burner was not known. The diminution in the consumption of gas for a given candlepower with incandescent burner was thought to be good cause for removal of the sulphur restrictions. Nevertheless the elimination of organic sulphur, as it is called, would be a welcome gain to the gas industry, for there is no gainsaying that the formation of even minute quantities of sulphuric acid in a room cannot but be harmful to furniture as it is to metallic fittings.

It is not likely that lime purification will again be resorted to on account of its tediousness, high cost, and uncertainty, and the difficulty of removing the malodorous product. Some hope of success is held out by the large scale experiments of Mr. Hall, of Portland, Oregon, the results of which have been recently published.

Mr. Hall has adopted the expedient recommended by Mr. Vernon Harcourt 50 years ago of simply heating the gas, leaving the purifiers to a temperature of 700° to 900° C. The probable reaction that takes place is represented by the equation $CS_2 + 2H_2O = 2H_2S + CO_2$. The heating takes place in brick chambers and the gas is afterwards purified a second time with iron oxide. The great bulk of the organic sulphur is said to be removed in this way, but nothing is known as to costs.

Liquid Purification: Seeing that a purifier box must be opened more or less frequently with attendant dangers of firing of the oxide by rapid revivification, the loss of gas and the subsequent admixture of a large quantity of air when the box is again put to work, a process of liquid purification in closed vessels has been much sought after by gas manufacturers. Partially successful attempts to solve the problem were made in the eighties by Hills, Claus and Holgate. The process then experimented with depended on the action of purified ammonia, obtained by the distillation of the gas liquor, in absorbing hydrogen sulphide and carbon dioxide. The experimental plants that were erected were discarded one by one. Their failure was due to the following causes: 1. Loss of ammonia. 2. Incompleteness of the reactions. 3. The costly nature of the plant and the supervision necessary.

Two or three years ago Dr. Feld launched a scheme for condensing and purifying coal or coke-oven gas. The gas was to be taken as hot as possible, say at 200° C., from the retorts and treated in a series of centrifugal washers. The tar was to be fractionated by hot washing into pitch, dry heavy tar and dry light tar. It was intended to extract ammonia in two washers and sulphuretted hydrogen in another set of two. One washer was to be used as a cooler. Thus it was proposed to perform the whole process of condensation and purification in one small building under the supervision of one man. Attempts have been made to work the process in Germany, but so far as I can gather, without complete success. There have been naphthalene and other troubles. The idea is brilliant and,I think, well worthy of a sustained effort to put into execution.

In the extraction of sulphuretted hydrogen Feld makes use of its reaction with sulphur dioxide. He at first used certain oils as the medium for carrying the sulphur dioxide and sulphur, the latter of which eventually crystallized out. This method has been abandoned in favor of a process which has been in operation on a small scale at Konigsberg and has just been started on a larger scale at one of the Hull gas works, where 1½ million cubic feet per day are being dealt with.

The active agent is zinc thiosulphate solution, made in the first instance by the action of sulphur dioxide on zinc sulphide formed from zinc oxide and sulphuretted hydrogen. Two Feld washers are used in the process and the reactions that take place are represented by the equations:

$$2ZnS + 3SO_2 = 2ZnS_2O_3 + S.$$
$$2ZnS_2O_3 + 6H_2S = 2ZnS + 6H_2O + 8S.$$

The most recent proposal by Feld is one that ensures a very complete extraction of ammonia to form sulphate simultaneously with the removal of sulphuretted hydrogen. It necessitates an elaborate chemical plant, however. The process is explained by the following equations:

1. First washing:
$$2FeSO_4 + 4NH_3 + 2H_2S = 2FeS + 2(NH_4)SO_4.$$
2. Regeneration of iron liquor:
$$2FeS + 3SO_2 = 2FeS_2O_3 + S.$$
3. Second and further washings:
$$2FeS_2O_3 + 4NH_3 + 2H_2S = 2FeS + 2(NH_4)_2S_2O_3.$$
4. Oxidation:
$$2FeS + 2(NH_4)_2S_2O_3 + 3SO_2 + 4O = 2(NH_4)_2SO_4 + 2FeSO_4 + 5S.$$

Then follows the filtration of the sulphur.

5. Final precipitation of iron:
$$2(NH_4)_2SO_4 + 3FeSO_4 + 4NH_3 + 2H_2S = 4(NH_4)_2SO_4 + 2FeS.$$

Then follows the filtration of ferrous sulphide, leaving a pure solution of ammonium sulphate.

New Appliances.—Gas Washers: Professor Burstall of Birmingham University, who also has a scheme for the fractional separation of tar, has recently devised and patented a gas washer and a fan tar extractor the ingenuity of which appeals to everyone.

Among the washers that have been introduced in recent years may be mentioned the Holmes brush washer, the Feld vertical centrifugal washer already referred to, and the new vertical centrifugal washer of Messrs. Kirkham, Hulett, and Chandler. The last named is very similar in its action to the Feld washer.

Gas Governors: In the works the retort-house governor is coming into general favor. It ensures greater uniformity of gas. The use of district governors to

regulate the pressure to consumers' meters is also being extended with beneficial results.

Gas Calorimeters: The "Boys" calorimeter was introduced by the Metropolitan Gas referees in 1905. It agrees closely in results with the Junkers and Simmance-Abady instruments and possesses peculiar advantages of its own.

Pyrometers: Of new instruments the Wanner electrical pyrometer is largely used in Germany. The Fery radiation pyrometer is in greater favor in England and France. The latest modification is the Fery radiation spiral pyrometer—a very simple and compact mechanism capable of taking temperatures of combustion chambers and retorts with the greatest convenience and celerity.

Recorders: Pressure. In a gas works it is highly desirable to have a record of pressure or vacuum at inlet of retort-house governor, inlet of exhauster, inlet of purifiers and outlet of holder. Every well-equipped works takes daily records of this kind.

Carbon Dioxide: Daily records of carbon dioxide in the waste gases from boiler furnaces, in crude carburetted water gas, or even in waste gases from retort settings, are of great assistance in controlling manufacture. Several ingenious contrivances for this purpose are now supplied.

Calorimetry: One of the latest advances is the recording calorimeter. Junkers' firm supply an elaborate and accurate calorimeter recording gross value. Messrs. Parkinson and Cowan supply a very simple mechanism which records net value. These instruments are of immense value to the gas manufacturer, as they promptly indicate any want of uniformity in the quality of the gas made, and this affords opportunity of rectifying a defect without delay. This is all the more important in these days when the uniformity of calorific value is so essential.

Carburetted Water Gas: In most gas works possessing a carburetted water gas plant this auxiliary to coal gas is only used either as a standby or as an enriching agent. That it is much cheaper to manufacture than coal gas is, I believe, the general opinion of the outsider. With oil at a comparatively high figure, as it has been for some years, carburetted water gas is probably on an average slightly dearer than coal gas, candle for candle.

One cannot say that any important improvements in water gas manufacture have been made in the last ten years.

Research Work.—There have been no contributions of great practical importance to our knowledge of the chemistry of carbonizing.

Improvements have been mainly physical and mechanical. The reactions that take place in the retort are as yet but little understood.

I would remind you of the bold experiment made by the Birmingham Gas Department in erecting five years ago as a test plant a complete gas works carbonizing 24 tons of coal per day. Hitherto we have not published any results, chiefly for commercial reasons. I may confidently say, however, that the remarkable improvement in the carbonizing results of the different works of the department is in large measure attributable to the test works, and justifies the considerable expense of its erection and working.

EFFICIENCIES OF COMBUSTION PROCESS COMPARED.*

By THEO. J. VOLLKOMMER.

Although much has been written on furnaces, producers and combustion, giving scientifically accurate calculations of heat balances, to the average furnaceman the meaning of these calculations is not clear, and he cannot reconcile the figures with actual conditions of operation. He is not concerned with how many molecular weights of carbon are contained in his coal pile, or how many molecular volumes of fuel gases pass through his gas flues. His interest is in the furnace which realizes the highest earnings on the investment under the special conditions which the nature and quantity of his products, the price of fuels and the wages of attendants impose upon him.

In the strictly scientific treatises the calculation of efficiency is based, not on the relation of the amount of heat absorbed by the article to be heated to the total heat supplied, but on the ratio of the heat units carried off by the waste gases to the total heat supplied. The shape and condition of the furnace, the radiation of heat through and by the walls, the effects of leaks, the effect of influx of cold air through the doors and other items are not considered at all, although they are likely to have the greatest effect on the economy of production. The following is not claimed to be a scientific deduction or calculation; it is merely intended to be a comparison of the relative efficiency of various modes of combustion. Even in the same heating furnace the efficiency will vary, as during the starting up a comparatively large amount of heat is absorbed by the brick walls, and when these are brought up to the normal heat, a new cool charge will absorb more heat than later when it is near the final temperature. In the beginning a cold charge may even absorb considerable heat radiated back into the hearth from the brick work, thus rendering the radiation of heat from the hearth temporarily negative.

CONDITIONS ASSUMED FOR THE COMPARISON.

To avoid complications caused by these changing conditions, in the comparison a furnace has been selected in which the absorption of heat by the body to be heated is nearly uniform—i. e., a muffle furnace, where the muffle is to be kept at a constant temperature. The temperature inside the muffle had to be kept at about 900 to 1,000 degrees C., which necessitated a temperature in the space around the muffle of about 1,200 degrees C. The maximum amount of heat which

*Iron Age.

can be absorbed theoretically by the muffle and the charge in the muffle is the difference between the heat furnished by the combustion of a unit of fuel and the heat carried off by the waste gases at 1,200 degrees, less the heat lost by radiation of the brick work around the hearth and combustion chamber. The latter varies considerably with different constructions of furnaces and with the temperatures in the hearth. For the purpose of comparison, the construction of the hearth of the furnaces is assumed to be the same in all cases and the heat lost by radiation to be in proportion to the temperatures in the hearth.

PERFECT COMBUSTION.

The combustion would be ideal if each atom of carbon would find and combine with two atoms of oxygen, and in case free hydrogen would combine with one atom of oxygen. With less oxygen, part of the fuel cannot be burned and escapes either without taking part in the combustion at all in the form of smoke (fine carbon particles) or hyrogen gas, or only gets partly oxidized as carbon monoxide. Even admitting the theoretically correct quantity of air, perfect combustion is nearly impossible and a certain excess of oxygen must be admitted.

Pure oxygen is too expensive to use in most industrial furnaces; air which is approximately one-fifth oxygen and four-fifths nitrogen is free. To maintain combustion with air, it is therefore necessary to admit with each part of oxygen four parts of nitrogen, which is entirely inert. Moreover, it must be heated to the temperature of the flame, and most of the heat furnished by the combustion is absorbed at once by this inert gas, thus reducing the temperature of the flame to about two-thirds of what it would be if only oxygen were admitted for combustion. This presumes the theoretical amount of air to be admitted. Practical considerations mentioned later require a certain excess of air; in the ordinary grate fire it amounts generally to about 100 per cent, thus making the total amount of air double the theoretical quantity. Heating this excess air to the temperature of the flame reduces the temperature to about two-sevenths of the temperature obtainable by the combustion in oxygen. The only but sufficient excuse for this waste of heat is that the cost of the fuel wasted is less than the cost of pure oxygen for the combustion.

COMBUSTION WITH NO EXCESS AIR.

Average Pittsburg coal contains 75 per cent carbon, 5.3 per cent hydrogen and 12.7 per cent ash and other combustibles. The following calculations are based on burning 1 lb. of this coal per unit of time. If it could be burned completely without excess of air and the fuel and air were admitted at 0 degree C. (32 degrees F.), the combustion would yield 13,755 B. t. u. sufficient to heat the combustion gases to 2,150 degrees C., which is, therefore, the maximum theoretical temperature obtainable by the combustion of coal in cold air.

It was stipulated before that the temperature of the gases leaving the hearth (or the space around the muffle) should be not less than 1,200 degrees C (2,192 degrees F.), at which they would contain 6,523 B. t. u., per pound of coal burned. The difference, 7,232 B. t. u., must, therefore, be absorbed either by the charge (or muffle) or by the brick work of the hearth and radiated.

Taking the heat radiated as proportional to the temperature, which is approximately correct, of these 7,232 B. t. u., about 1,500 B. t. u. might be radiated and the balance of 5,732 B. t. u. absorbed by the charge. Even in this purely hypothetical, in reality absolutely impossible case, only five-twelfths of the heat would be utilized in the strict sense, while seven-twelfths would be lost. In practical operation it does not matter how this heat is lost after the gases have left the hearth, whether by radiation in flue or stack, or with gases emitted by the stack, and this part is omitted from consideration.

COMBUSTION WITH 50 PER CENT EXCESS AIR.

Now consider the combustion of 1 lb. of coal with an air excess of 50 per cent, which is scarcely practical in a grate fire, as the stack probably would emit a fairly dense volume of smoke unless the coal bed was kept in a remarkably good condition. By substituting 1-10 gal. of fuel oil for 1 lb. of coal, both of which contain about the same number of B. t. u., it is entirely sufficient if the amount of air used for the spray and for final combustion exceeds the theoretical amount by 50 per cent. This is illustrated in Fig. 2. The same number of B. t. u. are liberated as before, 13,755, and if these are absorbed by the combustion gases, which now include 87 cu. ft. of air (when at 0 degrees), a temperature of only about 1,590 degrees C., or 2,890 degrees F., will be obtained. Even here this temperature will never be reached, because the combustion is not simultaneous and a small part of fuel gases will always escape unburned.

(To be concluded.)

According to a report of the U. S. Geological Survey, more briquets were made in the United States in 1909, than in any preceding year. Sixteen briquetting plants were in operation, but five of them were only working experimentally and two of these were making briquets from peat. The total product in 1909 was 139,661 short tons, valued at $452,697, an increase over the output of 1908 of 49,303 tons, or more than 54 per cent in quantity, and of $129,640 or 40 per cent in value. This output is insignificant compared with that of Germany, where 18,000,000 tons of briquets are made every year, but it shows that the briquet industry is at last getting started in the United States. The conditions in Germany, however, are very favorable to the success of the industry. Labor is cheaper, coal is dearer, and the wasteful "beehive" coke oven is unknown, for coal is coked in retort ovens supplied with by-product recovery equipment, which yields a large output of coal-tar pitch that is available for use as binding material.

THE PLANT.

ELECTRIC LIGHT IN THE CHEMICAL WORKS.

By WARREN H. MILLER.*

The difficulties involved in getting an electrical wiring system that will stay intact for any great time and also not introduce any additional fire hazard, are so great that it is often a grave question whether it is advisable to introduce electricity into the chemical plant at all. This is particularly true where either sulphuric acid fumes, or volatile explosive gases, or both, are prevalent about the works. It was the writer's privilege to devise the equipment now in use in the Bergenport Chemical Works, a large sulphuric acid chamber-process plant subsidiary to the Standard Oil Co., and also for the acid-restoring plant of the new Bay Way refinery. A brief resume of the problems involved may be of interest to those who are contemplating the installation of electricity in their plants.

There is little need to dilate here upon the extensive and all-pervading corrosion of sulphuric acid fumes. Practical acid men know well how, in the course of years, all iron-work, no matter how carefully protected by thick lead casings, becomes "sulphated," and the lead case resembles a bag full of salt sludge, unless carefully watched and often cleaned and painted. The sulphating action, once begun, is very hard to head off, and its lifting and prying power is simply incalculable. One easily recalls whole towers, of several hundred tons weight, lifted bodily from their foundations by the formation of sulphate under the feet of the main uprights. With electric wiring, run in all sorts of corners and crannies, sulphating is sure to occur, and, in a short time, the wires are grounded by the very good conductive power of weak sulphuric acid, and a fire rapidly ensues.

Now the average lead casing of insulated wire is not more than 1/32 in. thick, and, being drawn on through a die, this process itself introduces numerous minute pinholes in the lead, which are in a short time punctured by the weak acid which condenses on the wires, and, presently you have a ground between the wire and the lead case. Even if submerged in ordinary water, the grounding through these minute pinholes will show up in less than two months, at least that has been the writer's experience with lead-encased wires run under a water-power race 4 ft. deep. But, in a chemical works, the usual practice is to encase the iron-work in sheet lead of not less than 1/16 in. thickness, and this has no pinholes. It is rolled over the iron, and burned as carefully as possible. In spite of all this, it is only a matter of a year or so when the acid finds a weak point, penetrates to the iron below, and forthwith begins that insidious process of sulphating which will eventually end in the whole casing being pried off. By painting the wires with tar, they can be preserved intact for some little time, but still another difficulty is encountered in the use of lead-covered wire, about a chemical works, in making taps to it for lamp-sockets, cutouts, and branches. When you bare any wire you have just a scant 1/8 in. between the lead covering and the projecting end of the bare copper wire, and it will immediately ground if acid-laden air is allowed to come in contact with it. If you peel it back any distance, the lead covering must be burned to something, somewhere, in order to keep the acid from following on in, and it is impossible to burn it to anything without ruining the insulation.

In fine, the writer and Mr. Baldwin, the superintendent of the works, went over the use of lead-encased wire as thoroughly as possible, and, in view of the practical difficulty of keeping any lead-encased metal safe from acid attacks for any length of time, its use was abandoned in favor of some sort of a wood-and-tar encased conduit. About the most acid-resisting wood known to the chemical trade is hard long-leaf yellow pine. It makes a very satisfactory upright for tower stills, and, though it gradually chars if unpainted, in combination with tar paint it will last indefinitely about an acid works with a little cleaning and supervision. Electric two-wire and three-wire molding can be had in it, by specifying it, from any of the large manufacturers of this material, and there are several porcelain fittings that are made to fit flat down on the molding, entirely concealing all wires. That known as the "Fielding" porcelain receptacle comes in both 45° and 90° outlets, and, to get a light wherever wanted, it is simply needful to saw off a few inches of the molding cap and pull up the wires, baring them for half an inch where they cross the fitting. The porcelain cap is then put on and covers it completely, besides fitting tight to the molding cap, and leaving positively no entry for air, gas or water to the wires inside the molding. It seemed to us that this scheme would make a fair beginning for an acid-proof system of wiring. We decided to flow the molding full of hot tar, sink the wires in it, and nail on the cap while the tar was still hot, and thus get, in effect, a solid tar-and-hard-pine conduit in which the wires would be buried, being at no point nearer than

*Electrical Engineer, Standard Oil Co.

half-an-inch from the surface. For outlets there was the Fielding receptacle, which could be put on wherever wanted, and for branches and cutouts we devised a special branch-block, and adopted the plain cartridge fuse cutout, pouring a solid mass of hot tar over it when once the fuses were put in.

The wiring plan is shown in Fig. 1. To get uniform voltage throughout the works there are two systems available, the "star," in which mains are run to central distributing panels, and the "closet," in which the mains run to opposite sides of an enclosed circle of two submains. It is obvious that the total distance from any point in this circle is the same to the power house, so that the voltage is uniform, no matter where taps are taken off it. With the star system the further out you go on the submains leading off from the central panels the greater the drop, so it involves a somewhat more complicated arrangement and more branches than the closet. We therefore chose the "closet" because of its flexibility and simplicity, and arranged three of them, covering works A and B, and the still houses, C. For these heavy main wires, too

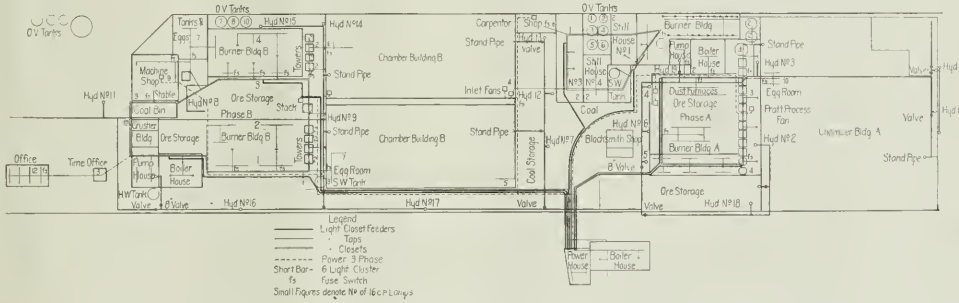


Fig. 1—Fire Protection Electric Wiring Plan—Distribution System.

large for molding, the best thing would be to run them on knobs always in plain sight and easy to get at and tar. Both they and the smaller wires inside the molding were "weatherproof" insulation instead of rubber-covered, the reason for this choice being, that, while the rubber insulation is quickly vulcanized by sulphuric acid fumes, the balata-gum insulation of the former is, to a great extent, impervious to such action. The positions of the closets were chosen to cover such an area that tails running out from them, either inward or outward, would reach any point of the plants where light was required, without putting more than six amperes on any one line. We decided to avoid having any lights at all in the chamber rooms, because these are only visited by the chamber-men at periodic intervals, when they carry a light from one test outlet to another. During the rest of the time they had best be dark, so that the watchmen can the quicker perceive any fires that might start. The places to light would be the still-towers, still-rooms, chamber tower-tops, burner sheds, egg rooms, process-fan rooms, main power and pump houses, and offices; also the crusher and loading dock, machine-shops, etc. It was thus easy to find suitable runs for the closet mains, and they were, for the most part, located outside on the roofs of the buildings, placed on poles along the parapet walls of the burner-sheds, etc. Along the rows of chamber towers, which had a common transite and tile roof over them collectively, the mains were strung in the lanterns on the cross-bar of the lantern truss. In the "C" closet of the five still houses, the mains crossed the ridges of the roofs on poles bolted to the lantern steel-work and taps entered each still-house by way of this pole and the lantern trusses. Once inside any of the buildings, the wiring ran entirely in the tar-molding conduit. This was run up the pole to a transite junction-box on the pole in which was located a Bryant combination switch and plug cutout with porcelain base and porcelain plugs. To protect the copper of the switch it was closed and painted with tar, and the box itself was practically impervious to fumes.

For distribution of the units of light, the Fielding receptacles were put right on the molding lines, run at about 8 ft. above the floor on the tower tops, and one was spaced at each tank. A molding drop was let down so as to place a light over each of the lead distributing troughs, with their multitude of pipes leading to each drip-hole, all of which must be frequently inspected to see that each gets its proper share of the acid. In the still houses it was found best to bunch the light in two large units of six 32 cp. lamps each, placed on opposite sides of each still house so as to light the still burners and acid and water troughs thoroughly. Another light was needed at the boot at the rear of the still-pan, and also one at the overflow of the trough of each still tower, but, beyond these two extra lights, it was best to concentrate the rest of the illumination in the two big clusters at the sides. Acid men do not have to be reminded of the continuous rolling clouds of fumes that are always flooding the roofs and lanterns of the still houses, and the less wiring of any kind in these places the better.

The clusters used for the still houses, the ore-handling yard and the tower alleys in front of the main chamber buidings, were all of six 32 cp. lamps, set in

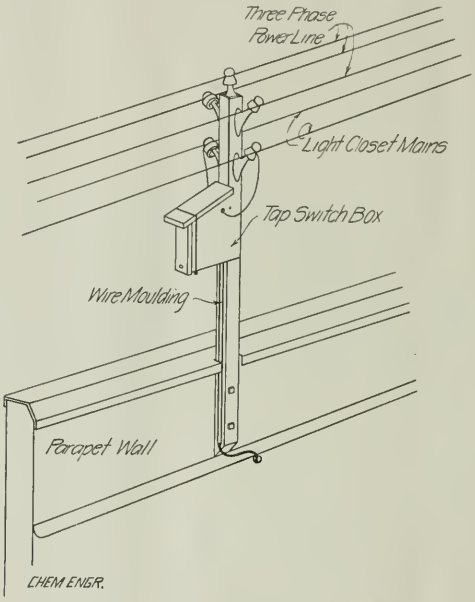
a row on a short piece of tar-molding about 30 in. long. The receptacles were all 45°, looking downwards to shed the rain, and were placed in little pine eaves, made by nailing a piece of 7/8 in. x 6 in. yellow-pine to a back-board of the same material, the upper board slanting to shed the rain. To this was nailed the bar of molding, and a cartridge cutout was put at one end. It gave a broad bar of light of 240 candlepower, and was a very practical substitute for arc lamps, as these latter are too vulnerable to acid corrosion to be of much use around a chamber acid plant.

For pendant lamps that were required to be flexible we used No. 14 solid "weatherproof," drawn into 3/8 in. circular-loom. The socket was porcelain with key, and the loom was secured to it with tape, wound over the base of the socket and the end of the circular-loom, and the whole tarred. They were very useful around such apparatus as rotary ore-dust furnaces, where several different places about the rotaries had to be examined.

In all these sockets throughout the works, there was still one place where the acid gases could penetrate, and that was the annular space around the base of the lamp, between it and the porcelain rim of the socket. It would never do to allow this space to remain open, and any form of rubber would be too perishable to be considered. We tried tarring the space up, but, as lamps had occasionally to be removed or backed out for testing for grounds, such a scheme was far from practical. The writer finally hit on the idea of turning up a ring of No. 14 weatherproof wire and slipping it over the lamp before screwing down. It exactly fitted into the space between the lamp-base and the socket, and, by giving it a single wipe of tar, it was absolutely impervious to moisture and acid. These rings could be fashioned by the electricians in great quantities and very quickly. All that was needed was to cut off a piece of wire of the right length and bend it around the lamp, making it a trifle small so that it would fit tight when the lamp was screwed home.

To make the tar-molding cable, the first plan was to get out the moldings in two-section pieces, each section being sixteen feet long. Two of these were placed end to end and the hot tar run in them, followed at once by the wire and cap. It took some rapid work to get the cap on before the tar hardened. The caps were fastened by 2 d. copper nails, spaced about 18 in. apart. These double sections were unwieldy to put up, handle, and make branches from, besides introducing a possible point of danger through careless workmanship at the splices to adjoining sections, which were every 32 feet. They were finally discarded in favor of the plan of putting up all the molding first, making a neat joiner's job of it and then putting in the wires and caps. All this molding was first dipped in a long trough of tar and then allowed to dry for several weeks. The pieces were then ready to handle, and the tar in a semi-plastic condition roughly filling the wire grooves. After putting up, the wires were run and pressed down into it. They were then given a thick mop of tar and the cap put on. This arrangement was really safer and better than the hard tar, which had to be put on hot, as the job did not have to be rushed so.

In all there were about 600 lamps in the plant. They were all 16 and 32 c. p., carbon filament, 220-volt lamps. While many opinions were expressed that the 220-volt filaments would be brittle and unsatisfactory, our experience with them was very good, and they are extensively used in the large Western manufacturing establishments. The reason for taking 220-volt was for the sake of simplicity. All the motive power of the works, for fans, elevators, shops, etc., was induction motors, three-phase, sixty-cycle, 220-volt, which supplanted the numerous small and



Method of Bringing Wires Into Buildings.

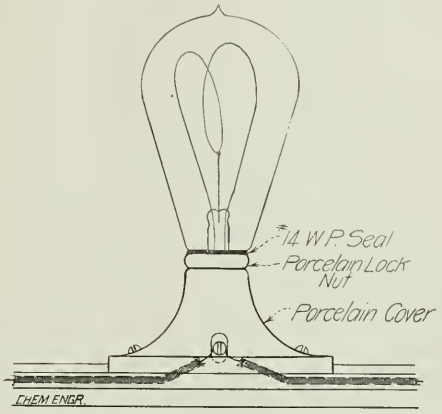
wasteful steam engines of the plant. For the sake of simplicity, and also for cheapness in avoiding banks of transformers and heavy 110-volt mains, the lamps were simply made 220-volt also, and the choice proved to be wise. Each of the three lighting "closets" were run off one of the three phases. While, theoretically, these should be balanced, for the sake of maximum efficiency in the generators, in actual practice we found that it made no great difference whether all the phases were on or not. As a general thing "A" and "C" were about equal and "B" slightly ahead, but often "C" would have only about half its light on, owing to benches of stills being down for cleaning, and this unbalancing caused no noticeable effects whatever at the power house.

This installation has been running for over three

years at present writing, and the wireing equipment is resisting the acid far better than any of the lead-covered iron work and lead distributors installed three years ago. The care of the plant has been very little. One electrician looks after all the light and power by day and the night foreman of works "B" has it under his eye during the night.

With the installation of electric light at the acid-restoring plant of the Bay Way refinery, this same method was used, but a new problem entered here, causing it to fail completely. This was the fact that the fumes of volatile oils, capable of dissolving tar, were present in great quantities in the vapor coming off the acid evaporating pans. This plant has seven benches of evaporating pans, each having a capacity of 140 tons of acid evaporated from 50° to 66°. The wiring plan is shown in Fig. 1. There is little use for light in the pan-rooms. The fumes are so thick that no light can penetrate, and the best equipment is a portable electric storage battery mine lamp, which the stillman can carry into the room with him to take readings. Nevertheless, clusters of six-light bars were installed in each pan-room, three to each room. In less than two weeks all these lamps were covered thick with a black deposit, so opaque that one could hardly make out the filament inside. In a month or so grounds became so bad that feeder fuses of double the normal capacity of the lines would blow, and an overhauling of the wiring showed that all the tar had been dissolved, both outside and inside the molding, and replaced by a thick oily, acid compound. The acid had attacked the wood of the molding and charred it soft and spongy, and the balata-gum of the insulation was soft and could be peeled off by hand like mud. Out in the yard and in the still-rooms everything was holding up pretty well, but in the pan-rooms the case was hopeless, and they were cut out of the circuit forwith. In the course of several months more, the same conditions of dissolved tar began to be manifest in all the still-rooms, as the air was fairly heavily laden with oil distillate fumes there also. As it was only a question of time when everything reached by these fumes would be in the same condition, a radical change had to be devised. Out around the yard, over the coal trestles, and about the treating tanks, the light was obtained by a form of Federal four-light cluster which could be made air tight by the addition of a rubber gasket under the rim of the outer globe. This was screwed into a galvaduct iron-pipe electric conduit arc-fitting, bent up out of 1-in. galvaduct, and the wires led into it from the aerial wires of the distribution lines. This seemed to stand the acid fumes pretty well, but it would never do for the stillrooms, so the plan devised for them was the use of lead pipe conduit of about C thickness and size equivalent to ½-in. iron pipe. This was threaded as well as possible and screwed into tarred "condulet" fittings. The caps of these fittings were all blank iron, and a sheet lead composition gasket, such as is used for automobile motor fittings was put under the blank, sealing it against gas and water. A ring of No. 14 weather-proof was put in between the lamp and socket of all these lamps.

In the original installation 40 c. p. tungstens were installed throughout, as all the sockets were fixed on rigid supporting walls and beams, and, in the nature of the process, there was no vibration. In spite of this, within a few months all the lamps were burnt out, and were replaced with G. E. M. metallic filament lamps, which stood up well to the work. It should be said, in justice to the tungsten lamp, that



Fielding Rosette on Tarred Moulding.

these were all of American manufacture, whereas this lamp is exclusively used in Europe without any trouble at all from breakage. The writer used over 5,000 of the American makes in the various plants under his charge, but the only lamp which stood the test of time was a single French tungsten, which lasted over a year in a 45° cluster in the machine shop at the Bay Way refinery.

Although the old Mexican standards for measuring water have long since been displaced by the metric system for engineering work, the old nomenclature is still in use among the common people and is found in the old records and writings. These ancient hydrometric measures are as follows: 1 buey (ox), 48 surcos; 1 surco (furrow), 3 naranjas; 1 naranja (orange), 8 reales or limones; 1 real (bit) or limon (lemon), 2 dedos; 1 dedo (finger), 9 pajas (straws). According to the old ordinances of lands and waters established in Spanish times, the buey of water was as much as would flow through an aperture 1 vara (0.838 meter) square, no head pressure being mentioned. By a law of the Mexican Republic of August 2, 1863, 1 surco was equal to 6½ liters per second for rural measures, and the paja was made equal to 0.45 liters per minute for town measurements. This distinction was intended to make the surco a unit for irrigation, while the paja was made unit for distributing water to houses, etc., in towns.

METALLURGY.

ALLOYS OF NICKEL AND COBALT WITH CHROMIUM.

The metals, nickel and cobalt, have always possessed a peculiar interest for the chemist. Like nearly all of the more recently discovered metals, their compounds were known before the metals themselves were discovered. Indeed, it has been known for centuries that certain substances were capable of giving a blue color to glass, and there is but little doubt that this peculiar power was due to some crude compound of cobalt.

About two centuries ago, the ores of cobalt and nickel were encountered in the mining of copper. It was at first supposed that they were ores of the latter metal, but the miners, after vainly striving to smelt the ore, and failing to obtain any copper from it, designated it as "Kupfernick," and from this expression the word "Nickel" originated.

Attempts were also made to smelt the ores of cobalt, but, as no useful metal resulted, they decided that the goblin, or "Kobold," supposed to inhabit the mines, had placed a ban upon the ore, and thus rendered it incapable of producing valuable metal. From this designation by the German miners, the name "Cobalt" was derived.

It was not until 1751 that Cronsted published the results of an investigation which he made upon an ore obtained from the mines of Helsingland. This ore yielded a brittle metal, and as it occurred most abundantly in "Kupfernickel," he suggested for it the name of "Nickel."

A few years later, in 1776, it was discovered that nickel was evidently one of the constituents of a Chinese alloy, known as "Packfong."

The use of nickel in German silver began about the year 1823. It was not, however, until 1857 that Messrs. Deville and Debray, the celebrated French chemists and metallurgists, prepared pure nickel by heating its oxalate in a lime crucible. From the pure metal thus obtained, wires were made, which showed a tensile strength superior to that of wrought iron. The wires also showed considerable toughness, and when polished, presented a bright, silvery appearance, and retained their luster for an indefinite period, under all ordinary atmospheric conditions.

A few years later, the art of electroplating nickel was discovered, and has since received a very wide application. Tons of the double sulphate of nickel and ammonia are used for this purpose every year.

Besides the latter important application of the metal, it is now used in large quantities for the manufacture of nickel steel, which may become a common substance in the making of naval guns, projectiles, armor plate, and high-class automobiles.

The history of cobalt is similar to that of nickel, excepting that the *compounds* of cobalt were used in the arts, instead of the metal itself. In fact, but little was known of the metal until 1857, when Deville produced the pure metal in practically the same manner that nickel was prepared. It was found that cobalt was even stronger than nickel, possessing a tensile strength of 65,000 lbs. per square inch. Indeed, up to that time it was the strongest pure metal yet discovered, and it still holds this position, with the possible exception of tantalum.

About the year 1895, I made a number of tentative experiments, relating to the production of alloys of nickel with iron, chromium, and other metals. The fusions were made in small graphite crucibles, which were heated in a blast furnace of the Fletcher type, operated by natural gas. I had at that time, the advantage of natural gas at a pressure of 40 lbs. or more per square inch. With a suitably arranged furnace of this character, temperatures ranging up to the fusing point of the most refractory Missouri fire clay, were readily obtained. I succeeded in obtaining by this means, alloys of nickel and chromium, which contained, however, a considerable amount of carbon and silicon. A small quantity of aluminum was sometimes added to the alloy, in order to improve its quality. By this means, I obtained an alloy of chromium, nickel, and aluminum, which was hard and brittle, but possessed fairly good color and luster. From this alloy, a knife blade was formed, which showed fair cutting qualities, and considerable resistance to atmospheric conditions. It was readily soluble in nitric acid, and after long exposure to the atmosphere of a chemical laboratory, it became tarnished, showing a greenish coating on its surface.

Later, I attempted to produce alloys of nickel with chromium and titanium by means of an electric furnace, made from blocks of quick-lime. This proved unsatisfactory, but I continued experimenting with the gas furnace, and finally succeeded in producing an alloy of nickel and chromium free from carbon, by heating the pure mixed oxides of the two metals, with powdered aluminum, in a crucible lined with pure oxide of aluminum. The reaction was so violent that most of the metal was thrown from the crucible. A few small pellets were saved, and these showed great malleability, flattening readily under the hammer, without cracking. The alloy possessed a fine color, and when polished, exhibited a beautiful luster. Larger pellets were soon obtained, and it was found that when the chromium content much exceeded ten per

cent, that the alloy showed remarkable resistance to chemical reagents, particularly to nitric acid.

At about the same time, I reduced a mixture of the sesquioxides of cobalt and chromium, with powdered aluminum, and thus obtained minute pellets of an alloy of cobalt and chromium. The little particles thus obtained were not much larger than pinheads. They were found to be remarkably hard, and could scarcely be scratched by a file. A few of them were ground off on one side by means of carborundum, and showed a brilliant luster. It occurred to me that the metal might become serviceable for cutting instruments.

A short time after the above experiments were made, I was called actively into the automobile business, and thus compelled to abandon further experiments along this line for some time.

In 1905, I repeated some of the former experiments, with a view to utilizing the alloys of cobalt and nickel with chromium, for ignition points, in connection with gas engines. I was soon able to produce both the alloys of nickel and cobalt in considerable quantity. I ascertained that the nickel-chromium alloy could be worked cold, while the cobalt-chromium alloy must be worked hot in order to obtain any degree of satisfaction.

The first pellets of the cobalt-chromium alloy, weighing from 15 to 30 grams, were obtained by heating mixtures of aluminum with the oxides of cobalt and chromium, in crucibles lined with oxide of aluminum. Some of these pellets were heated to redness, and flattened out under the hammer, and while this could be done without cracking the alloy, the metal was found to be very hard, even at red heat.

I soon found that it was impracticable to reduce the alloy in this manner in large quantities. I accordingly purchased a considerable amount of pure cobalt and pure chromium, and had a mixture of nearly equal parts of these metals fused in an electric furnace, the metals being placed in a carbon crucible lined with pure magnesia. The alloy was cast into a small bar, about ¼ in. square, and 5 or 6 inches long. This alloy exhibited most of the characteristics of that reduced with aluminum, but it could not be drawn to any extent under the hammer without cracking. Whether this was due to the high percentage of chromium, or to slight impurities in the metals employed, I am as yet unable to say.

In order to determine the effect of alloying the cobalt with smaller percentages of chromium would be, I again had recourse to the gas furnace, and succeeded in melting a mixture containing 75 per cent. cobalt and 25 per cent. chromium in a crucible made of a very refractory material, which I compounded for the purpose. Much to my satisfaction, I succeeded in melting this alloy to a perfect fluid, and poured it into an ingot mold, which gave me a bar of metal about ½ in. square, and 5 or 6 ins. in length. This metal proved to be very sonorous and elastic, and if some care were used, it could be hammered out into a rough strip.

After a considerable amount of experimenting with various purifying agents, I finally succeeded in producing a very tough and malleable alloy, which could be hammered into the thinnest sheet at a bright red heat, without showing any sign of cracking. A razor blade was made from a bar of this alloy, and while it did not prove equal to the best steel for this purpose, it has been used hundreds of times for shaving purposes, and after a year and a half, shows practically no signs of wear, though of course it has been necessary to strop it frequently, in order to keep it in good condition. This bar was made about two years ago, and I am sure that I have since produced metal that would be much more satisfactory for the purpose.

A test of the tensile strength and elastic limit of this material was made, with the results as follows: Elastic limit, 79,000 lbs; tensile strength, 96,000 lbs., and elongation, 3 per cent. It will be seen from the above that both the elastic limit and tensile strength of this material are superior to those of untreated steel, resembling more nearly those of good nickel steel. The elongation is quite low, but this is to be expected, on account of the great hardness of the alloy, which is equal to that of mild tempered tool steel. A test was also made of the modulus of elasticity of this material, which was found to be about equal to that of steel. This is a very significant fact, since heretofore, it has not been possible, so far as I am aware, to form an alloy of non-ferrous metals, which would show a modulus of elasticity comparable to that of iron or steel. And it is lack of this valuable property in various non-ferrous mixtures, which renders them inferior to iron for many important purposes.

A pocket knife blade and several table knife blades were made from this material, and were found to be very satisfactory in every respect. One of these table knife blades has now been in use for more than two years in the kitchen, where it was used for all sorts of purposes, such as cutting bread, turning griddle cakes, peeling and paring vegetables, and for various other purposes, such as are known only to the culinary art. After all this use and abuse, the knife shows not the slightest trace of tarnish, and has held its luster so well that when exposed to the sun, it shows a reflection which dazzles the eyes.

By mixing the alloy with small quantities of other substances, its properties may be modified to a remarkable degree. By this means, I have obtained alloys or combinations which, while very brittle, would readily scratch quartz crystal.

By reducing the quantity of chromium to some extent, and adding certain other materials, alloys which are practically proof against nitric acid can readily be obtained, which are sufficiently soft and malleable to be worked cold, having a hardness not much greater than mild, untempered steel.

Between these two extremes, a great variety of

combinations can be made, which are suitable for use for various purposes. For example, I have produced an alloy of sufficient hardness that when it is formed into a small bar, say ½ in. wide, ¼ in. thick, and 3 ins. long, and one of the ends shaped for a cold chisel, a 20-penny nail can be cut in two without marring the edge of the chisel in the slightest degree. I have formed another alloy into a small lathe tool, about ¼ in. square, and 3 ins. long, which showed cutting qualities comparable to high speed tool steel. In fact, in some respects, especially under high speed and light cuts, it has stood the test for a long time, where high speed steel failed almost instantly, on account of the intense heat generated. I wish it distinctly understood, however, that I do not recommend this material, as yet, for lathe tools, though it would have a high value for this purpose, if it were not obliged to compete with alloy steels.

An alloy of 75 per cent. cobalt and 25 per cent. chromium, to which small quantities of other metals are added, is not only sufficiently hard for good edge tools, but is quite tough, and can be bent much beyond its elastic limit without cracking, resembling in this respect the alloy steels, but generally speaking, it is much harder. A bar of the alloy, ¼ in. square, can be bent cold at right angles, without showing any signs of cracking.

CHEMICAL PROPERTIES.

When a mixture of cobalt and chromium is heated to whiteness in a crucible, the cobalt first commences to fuse, and immediately begins to combine with the chromium, and if the metals are mixed in the proportion of about three parts, by weight, of cobalt to one part of chromium, a eutetic is formed which seems to possess a lower melting point than either cobalt or chromium. This is all the more remarkable because the melting point of pure, carbonless chromium is exceedingly high.

The color of the alloy lies between that of steel and silver, and is especially pleasing in bright light. The alloy is also readily polished, but requres special treatment in order to develop its highest luster.

The most remarkable property of this combination, however, is its resistance to corrosion. It is equalled in this respect only by gold and the metals of the planinum group. It is attacked slowly by dilute hydrochloric acid, and somewhat vigorously by the strong acid, especially when heated. Momentary exposure, however, either to dilute or strong hydrochloric acid, has practically no effect upon the metal. Both strong and dilute sulphuric acid attack it very slowly when cold, and not very rapidly even when heated. Nitric acid is totally without action upon it, and a polished piece of the alloy may be boiled in that substance for hours, without affecting the luster of the metal in the slightest degree.

Solutions of the caustic alkalies are also totally without action upon it even when boiled for hours. The alloy is likewise proof against all atmospheric influences, whether the air be moist or dry, and retains its brilliant luster for months, or even years, under severest conditions. Even sulphuretted hydrogen, when present in the atmosphere in large quantity, is totally without action upon it.

Its resistance to culinary operations has already been mentioned.

When the metal is heated in contact with the atmosphere, it retains its color up to a temperature approaching a dull red, or about 500° C., when it shows a faint straw color, which deepens as the temperature rises, passing through bronze-yellow, purple, blue, and finally terminating in blue-black.

The alloy shows no scales, even when heated to a bright orange, and the film of oxide does not seem to increase in thickness after prolonged heating.

It can readily be melted in an open crucible in a gas furnace, with practically no oxidation, so long as a slightly reducing flame is maintained. This is all the more remarkable, on account of its high melting point, which seems to be about 1650° C., for the 25 per cent. alloy. Indeed, the metal has been melted in this manner with a loss of less than one-half of one per cent.

USES.

The uses for any substance may be limited in several particulars; first, by the limitations of its fitness second, by the possibility of producing it in proper form, and third, by its cost. This material is particularly suitable for all kinds of small cutting instruments, since it takes an edge comparable to that of tempered steel. It is especially adaptable to the manufacture of pocket knives, on account of the beauty of its color, and the brilliancy of its luster, both of which remain permanent under all circumstances, thus giving the blades a particularly attractive appearance. Knives of this description may be used for cutting fruit, without danger of marring their luster in the slightest degree.

Alloys in certain proportions will also doubtless find a wide use for surgical instruments, since they resist perfectly all sterilizing solutions.

The alloy is perhaps better adapted for table cutlery than anything that has ever yet been produced. We all know too well that a silver plated knife, for example, is ill adapted for cutting meat, and it cannot be sharpened without destroying the plating. Steel knives, on the other hand, while they cut well, require endless labor to keep them in presentable condition, and at best are unsightly in appearance.

The alloy is also of considerable interest to the chemist and physicist. It is admirably adapted for the manufacture of fine weights for balances, scrapers, spatulas, and other laboratory appliances. To the physicist, it furnishes a material that is at once hard, lustrous, and untarnishable, and hence well adapted for the manufacture of fine weights, measuring instruments, and various small tools.

The alloy is also particularly well adapted for the manufacture of standard weights and measures, such

as the gram, kilogram, meter, etc., and it is difficult to see in what respect it is inferior for this purpose to the expensive platinum-iridium alloys now in use.

The alloy could readly be made into laboratory vessels, cooking utensils, spoons, forks, etc., and is limited in this respect only by its cost.

COST.

Regarding the cost of production and manufacture, I am not at present prepared to make definite statements. I have succeeded, however, not only in obtaining the raw material at lower prices, but have also reduced the cost of production to a considerable degree, so that it is now possible to produce the alloys with as much dispatch and precision as is possible in the production of common alloys.

In conclusion, I wish to add that the chemist seldom receives much credit or pecuniary reward for the discoveries which he is constantly wresting from Nature, and handng down to the engineer and manufacturer. Even the inventor usually receives more credit for his work that the scientist or discoverer, who often furnishes him with the facts and materials which render his invention possible.

The following table from the Journal of the Society of Chemical Industry shows the mine products or classes of products obtained from petroleum, together with the yield of each class in percentages and the total production in the United States in 1909:

	Kind of product.	Per cent. Yield.	Amount. Bbl.
1.	Kerosene	20.50	15,000,000
2.	Lubrication oils of all kinds including greases	10.00	7,000,000
3.	Naphthas, all grades	15.00	11,250,000
4.	Gas oil, used for enriching water gas in large cities	30.00	22,000,000
5.	Paraffin wax	1.50	1,125,000
6.	Roofing pitch	2.50	1,875,000
7.	Paving pitch and road-making oils	2.00	1,500,000
			Tons.
8.	Coke	3.00	300,000
			Bbl.
9.	Fuel oil	14.00	1,050,000
		98.50	
	Loss in manufacturing	1.50	
	Total	100.00	

The Dominion Department of Mines is stated to have recently conducted a successful demonstration of peat fuel from the government plant at Alfred, Ont. Several hundreds tons of this fuel are being brought to Ottawa and sold at $3.25 per ton delivered, which makes it equivalent to hard coal at less than $6.00 per ton.

EIGHTEENTH GENERAL MEETING OF THE AMERICAN ELECTRO CHEMICAL SOCIETY.

The preliminary program of the Chicago meeting of the American Electr. Chemical Society, Oct. 13, 14 and 15, as far as arranged is as follows:

Thursday A. M.—Reading and discussion of papers.

Thursday P. M.—Excursions, places not yet arranged.

Thursday Evening.—Subscription dinner, ladies especially invited.

Friday A. M.—Reading and discussion of papers.

Friday P. M.—Excursions: (1) South Chicago and the steel plant. (2) Gary, Ind. (3) Buffington Cement Works.

Friday Evening.—Smoker, entertainment by Section Q.

Saturday A. M.—Reading and discussion of papers at the University of Chicago. Luncheon at the University Commons.

Saturday P. M.—Field Columbian Museum, a football game, possibly a championship series baseball game.

The hotel headquarters will be the Congress Hotel, the sessions of Thursday and Friday mornings being held in the Florentine Room.

The entertainment of the ladies will include a luncheon, automobile trip and other special features, details of which have not yet been arranged.

During the first two months of 1910 the imports of coal into France amounted to 2,193,749 tons, as against 2,432,963 tons in the corresponding period of 1909. The imports of coke amounted to 340,960 tons, as against 308,067 tons in the 1909 period, and the imports of briquettes totalled 148,163 tons, as against 163,762 tons. Of the coal imports, 1,333,367 tons were from Great Britain, as against 1,586,690 tons in 1909, while of the imports of briquettes Great Britain contributed 16,854 tons, as against 20,987 tons in the 1909 period. The exports of these fuels from France during the first two months of this year, as compared with the corresponding two months of 1909, were as follows: Coal, 185,334 tons, as against 139,165 tons; coke, 28,101 tons as against 26,475 tons; briquettes 23,779 tons, as against, 30,810 tons.

An appropriation of $1,175,040 has been made for the U. S. Geological Survey for the fiscal year ending June 30, 1911. This is $232,350 less than the amount appropriated for the Survey for the fiscal year 1910, but the work of analyzing and testing fuels and the investigations of the causes of mine accidents were transferred from the Survey to the newly created Bureau of Mines, and the tests of structural materials were transferred from the Survey to the Bureau of Standards, with consequent transfer of appropriations An increase of $75,000 was made in the appropriation for geological work and of $50,000 for steam gaging.

BOOKS RECEIVED.

VAN NOSTRAND'S CHEMICAL ANNUAL; editor John C. Olsen, A. M., Ph. D. Published by the D. Van Nostrand Company; price $2.50.

The second issue of this chemical annual has recently been placed on the market. This issue contains considerable new material and the entire contents have been revised and corrected where necessary. The book as it stands contains practically all of the chemical and physical constants which are required in making any chemical calculations. Of its kind, it is one of the best books published in English.

CHEMIST'S POCKET MANUAL; by Richard K. Meade, M. S.; second edition; Chemical Publishing Company, Easton, Pa.

This is "a practical hand book, containing tables, formulas, calculations, information, physical and analytical methods for the use of chemists, chemical engineers, assayers, metallurgists, manufacturers and students."

The book contains the various tables which are needed in making chemical calculations and in addition to this it has descriptions of many important operations, such as methods for making solubility determinations, methods for standardizing weights, calibration of chemical glassware, etc. Directions are given for the preparation of the common reagents used in Quant. and Qual. Analysis.

About 150 pages are devoted to select methods for technical analysis and we find described here the methods commonly used in the analysis of the chief technical materials.

The output of finished iron and steel in Russia during 1909 totalled 2,572,000 tons, as compared with 2,335,000 tons in 1908. The totals for these two years respectively included the following items: Merchant iron, 851,000 tons and 893,300 tons; rails 467,400 tons and 325,400 tons; thick plates and sheets, 240,300 tons and 265,100 tons; thin plates and sheets, 332,700 tons and 288,400 tons; joists, 147,500 tons and 128,500 tons.

The Canadian Peat Society, which has been lately formed to advance the peat industry in Canada, will hold a meeting in Ottawa about the first week of December, to discuss practical questions involved in putting the manufacture of the new fuel on a commercial basis, throughout Canada wherever workable bogs are found.

The U. S. Forest Service is using ten tons of seed for restocking the National Forests. Most of the seed, it appears, is being sown broadcast in places which require restocking, largely burnt areas. The Government has, however, no less than 24 forest nurseries with an annual productive capacity of over 8,000,000 seedlings.

LOW-CARBON STREAKS IN OPEN-HEARTH-RAILS.*

By M. H. WICKHORST.†

During 1908 and 1909, the Chicago, Burlington & Quincy Railroad Company obtained some open-hearth rails which developed a peculiar kind of failure, the study of which proved very interesting. The nature of the failure caused considerable alarm at first, but the remedy was easily applied after the cause was determined. The failures consisted of the rails splitting through the head in various directions, through the web vertically or diagonally, vertically from the head

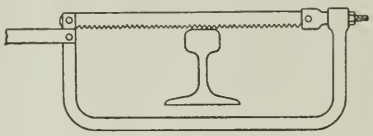


Fig. 1.

to the base, and in other ways. As a part of the investigation, the rails were examined by cutting sections from the defective portions, polishing highly, and etching with picric acid solution in alcohol. The method of preparing, etching, and photographing the rail section was about as given in the following description of a method for etching rails.

RAIL ETCHING.

Preparation of Section.—A slice of the rail ¼ in. or more in thickness is cut with a cold saw or circular

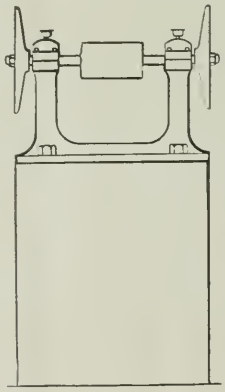


Fig. 2.

cutter, care being taken to get the cut surfaces as even as possible. Where available, probably the quickest and most satisfactory method is to use a circular saw. In case a machine-driven hack saw is used, it is best to have the saw frame in an inverted position, with the

*Paper read before the Thirteenth Annual Meeting of the American Society for Testing Materials, Atlantic City, N. J., June 28-July 2, 1910.

†Chief Chemist Chicago, Burlington & Quincy R. R., Aurora, Ill.

frame surrounding the rail (see Fig. 1), so that the weight of the frame may hang below the cutting blade, as this position is more apt to give a straight cut.

After the slice is obtained, one of the cut surfaces is filed or planed to a plane surface. The rail slice is then secured in any hand-clamps suitable for holding the section during the polishing operations. In polishing the rail sections, cast-iron discs at least 12 ins. in diameter are used, as shown in Fig. 2. Emery cloth is attached to the face of the disc, preferably by means

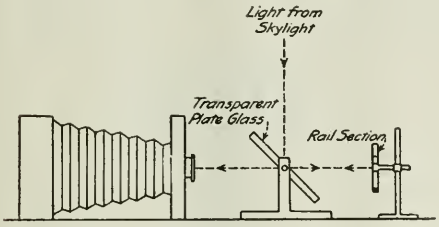


Fig. 3.

of a fairly light coat of rather soft asphalt. The rail section should first be ground with No. 1 emery cloth and then with No. 00. The section is then polished with tripoli and finally with rouge. These polishing powders are applied in a moist condition to a canvas-covered disc. When the surface is intended for further examination with the microscope and microphotographing, a very high mirror polish is necessary and the surface must be free from even very minute

Fig. 4.

scratches, such as show only under the microscope. When, however, it is intended only to examine for structural defects and streaks, so high a polish is not necessary.

Etching and Its Interpretation.—The rail section is etched by holding it in a tray of a five per cent solution of picric acid in alcohol. The etching generally requires from one to two minutes. When the rail section is taken from the acid, it is wiped with cotton saturated with alcohol. The picric acid does not color the ferrite or carbonless part of the steel structure; but the carbon-bearing part is colored somewhat in proportion to the content of carbon.

Photographing.—As the picric acid has no effect on the ferrite or carbon-free iron, streaks of low-carbon material are left with their full brightness, and in order to show these streaks properly, the light in photograph-

Fig. 5.

ing should be reflected perpendicularly from the specimen into the camera. A desirable arrangement is shown in Fig. 3, where daylight from a skylight is thrown on an oblique plate of glass, reflected onto the specimen, and then perpendicularly back through the glass into the camera. It is practically the same arrangement as the vertical illuminator used on a microscope.

Fig. 6.

SOME TYPICAL FAILURES.

When etched as above described, most of the split rails showed light streaks or patches, indicating streaks of metal low in carbon. Some typical etched sections of 90-lb. rails are shown in Figs. 4 to 9 inclusive, and it will be noticed that the failures occurred along the streaks. The rails shown in Figs. 8 and 9 had light

areas big enough to allow getting samples for analysis, and the results obtained are as follows:

	Rail in Fig. 8.		Rail in Fig. 9.	
	Normal.	White Band.	Normal.	White Band.
	Pct.	Pct.	Pct.	Pct.
Carbon	0.69	0.28	0.78	0.35
Phosphorus ..	0.037	0.091	0.036	0.073
Sulphur	0.034	0.048	0.030	.....
Manganese ...	0.94	0.64	0.85	.....
Silicon	0.15	0.09	.....	0.15

Fig. 7.

Fig. 8.

Small white streaks examined under the microscope generally show a nucleus of slag, indicating that the slag in some way causes a reduction in the amount of carbon. The rail shown in Fig. 9 also contains a large mass of non-metallic material contiguous to the white band; so it was at first thought that slag in the metal caused the white streaks, possibly by oxidizing the carbon. This may perhaps be true of small streaks, but it was later learned that it was the practice at the mill that made these rails to put small soft Bessemer steel plates on the stools of the molds to reduce the cutting out of the stools by the hot metal. These plates, it seems, get churned up with the rest of the metal, melt partly or wholly, but before becoming thoroughly mixed with the main body of steel, the metal sets, leaving streaks as shown in the figures.

Fig. 9.

It had been thought that the first metal poured would set and hold the plate at the bottom of the ingot, where it would be sheared off; but as soon as it appeared that the plates caused streaks as shown, the practice was promptly stopped. A few similar failures have been noted in rails from other mills, but whether due to a similar cause has not been determined.

The California State Mining Bureau places the value of the petroleum produced in California in 1909 at $32,398,187 and the value of asphalt, bituminous rock and natural gas at $2,440,537. This makes the valuation of the hydro-carbons produced $34,838,714.

The imports of iron ore into Belgium during the first half of 1910 amounted to 2,527,792 tons, or 470,525 tons more than the 2,057,267 tons imported in the corresponding period of 1909. The exports during the first half of this year totaled 276,824 tons, or 75,387 tons more than in the first half of 1909, when the exports amounted to 201,437 tons.

The exports of phosphate from Tunis in 1909, according to U. S. Consular Agent Auguste J. Proux, were valued at $5,923,000, against $6,117,000 in 1908. The leading producer is the Société des Phosphates et du Chemin de Fer de Gafsa.

The CHEMICAL ENGINEER

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NOTES AND COMMENTS.

The Training of the Chemical Engineer.

The course in Chemical Engineering in our colleges has been instituted for a comparatively short time. The majority of the men practicing the profession of Chemical Engineering have received their training primarily as chemists, or in other engineering lines, and have received either their engineering training or their chemical training by actual experience in the works.

We are now, however, approaching the time when the majority of the men in the profession will be recent graduates from courses in Chemical Engineering from our colleges and technical schools. There is, however, much diversity of opinion in the various schools as to what is requisite in the training of a Chemical Engineer.

Many of the courses in Chemical Engineering have been put in rather as a tail for the kite of the department of chemistry with the object of holding the student who would elect the course in Chemical Engineering in preference to a course in Chemistry. In schools of this class we find given in the Chemical Engineering course the maximum amount of work in chemistry and the minimum amount of work in the engineering subjects. In contrast to this we find the school where training in the engineering subjects takes foremost position and the study of chemistry is relegated to the background.

The profession being a new one, the effect of this variation in training on the young graduate cannot as yet be accurately estimated. Thus far we have received no expression of concerted opinion from the older members of the profession in regard to the proper training of the Chemical Engineer.

The American Institute of Chemical Engineers appointed a committee some years ago to investigate the course in Chemical Engineering offered in our American and, possibly in European and technical schools. Thus far this committee has only reported progress, but has not made any report of the conditions as they find them.

It seems to the editor eminently desirable that something be done in order to bring about more uniformity in the work offered in our various schools to students in Chemical Engineering. The youth of the profession is the only excuse to offer for not having these courses as uniform as those in civil, mechanical or electrical engineering.

It seems eminently desirable at this time to secure an expression of opinion from the older members of our profession as to the lines along which the training of the under graduate should proceed, that we may fit him in the best possible manner for work in his profession.

The editor will express his opinion, hoping that this expression may induce others either to criticise this or present opinions of their own. First the Chemical Engineer must have a thorough foundation in the principles of inorganic and organic chemistry; he must have considerable training as an analyst. These statements will probably be accepted by all. When we come, however, to outline the remainder of the course, we enter debatable ground. It is the editor's opinion that the student should have considerable training in mathematics and in both free-hand and mechanical drawing. He should also have a good fundamental knowledge of mechanical and electrical engineering, in so far as these branches may apply in the operation of a distinctly chemical industry. He should have a knowledge of metallurgy primarily from the standpoint of the suitability of the various metals and their alloys as materials to be used in construction work. He also should spend considerable time in the study of industrial chemistry, this subject, however, to be taken up not so much with the idea of becoming familiar with the details of the various processes employed in the manufacture of the chief industrial products, but taken up with the idea of familiarizing the student with the fundamental operations common to many of the chemical industries. He should particularly receive instruction as to the methods to be employed in determining the efficiency of the various pieces of apparatus that may come under his supervision.

He should be taught to take sufficient data on any process, such that the cost of manufacture of the article may be computed. This will mean of course that his laboratory work in industrial chemistry shall consist in carrying out actual manufacturing operations, using the same apparatus which will be used commercially. Throughout this laboratory work he should be increasing his skill as an analyst by keeping a strict chemical control of his manufacturing operations.

During this course, he should apply his knowledge of materials of construction, machine design, and mechanical engineering, with the view of making more efficient the machines in commercial use for the various chemical operations.

This is suggested as a brief outline of the fundamentals in a chemical engineering course; the details may be varied considerably without materially affecting the efficiency of the training of the young chemical engineer.

RECENT PATENTS.

The following patents have been reported for the Chemical Engineer by C. L. Parker, solicitor of patents, McGill Building, Washington, D. C.:

965,860. Composition of Matter to Be Used in the Manufacture of *Imitation Leaded Glass*. Arthur Ernest Bernasconi, Coventry, England. Patented August 2, 1910.

965,871. Manufacture of *Iron-Nickel-Copper Alloys*. William H. Clamer, Philadelphia, Pa. Patented August 2, 1910.

965,908 *Detergent*. Edwin E. Johnson, San Martin, Cal. Patented August 2, 1910.

966,136. *Compound or Emulsion* and Production of Same. Julius Stockhausen, Crefeld, Germany. Patented August 2, 1910.

966,324. *Food Product*. Dittmar Finkler, Bonn, Germany. Patented August 2, 1910.

966,366. *Waterproofing* and Preservative Paint or Composition. Lisette Schott, London, England. Patented August 2, 1910.

The paint consists of pure silver in powder one ounce, borax four ounces, and a vegetable oil one pint, heated together for from fifteen to eighteen hours.

966,389. Wet Process for the *Treatment of Ores* Henry Thomas Durant, Henry Livingstone Sulman, and Woldemar Hommel, London, England. Patented August 2, 1910.

966,399. Process of *Purifying Electrometallurgical Products*. Francis W. Higgins, Niagara Falls, N. Y. Patented August 2, 1910.

966,559. *Water-Purifying Compound*. Samuel Otis Johnson, Key West, Fla. Patented August 9, 1910.

966,636. *Lubricant*. Edward Goodrich Acheson, Niagara Falls, N. Y. Patented August 9, 1910.

966,814. *Varnish*. Ferdinand Ephraim, Santa Barbara, Cal. Patented August 9, 1910.

967,072. Process of *Separating Nickel and Copper* from Mattes. Darius P. Shuler, Sudbury, Ontario, Canada. Patented August 9, 1910.

The process consists in finely dividing the matte, subjecting the same to the action of diluted sulphuric acid to dissolve out the nickel, and in maintaining a sufficient quantity of hydrogen sulphide in the solution to prevent the copper from being dissolved, substantially as described.

967,105. Process for the *Separation of Gaseous Mixtures* Into Their Elements. Georges Claude, Nogent-sur-Marne, and Rene Jacques Levy, Boulogne-sur-Seine, France. Patented August 9, 1910.

967,185. Process of Manufacturing an *Explosive Compound*. Loftus Gray, Cleveland, Ohio. Patented August 16, 1910.

967,200. Electrolyte and Method of *Electro-Depositing Zinc*. Edward F. Kern, Knoxville, Tenn. Patented August 16, 1910.

The process consists in electrolyzing a solution containing fluo-silicate of zinc, fluo-silicate of aluminum and grape sugar, and adding ammonium fluoride thereto from time to time during the electrolysis.

967,246. *Fire-Extinguishing* Compound. Antenor Sala, Mexico, Mexico. Patented August 16, 1910.

967,335. *Steel Manufacture*. Jesse M. Darke, Lynn, Mass. Patented August 16, 1910.

This is a method of compounding an alloy, which consists in melting some of the components under protection of slag, and then introducing through a tube connecting with the mixture below the surface thereof a component having high chemical affinity for said slag.

967,337. Process for Treating *Asphaltum* to Make Varnish David T. Day, Washington, D. C. Patented August 16, 1910.

967,397. Manufacture of Threads, Filaments, or Bands of *Cellulose*. Albert Lecœur, Rouen, France. Patented August 16, 1910.

967,580. *Welding Composition*. Heinrich L. J. Siemund, New York, N. Y. Patented August 16, 1910.

967,584. *Casein Derivatives* or Compounds and Process of Making Same. Rudolf Tambach, Ludwigshafen-on-the-Rhine, Germany. Patented August 16, 1910.

967,590. Manufacture of *Steel*. William R. Walker, New York, N. Y. Patented August 16, 1910.

The method consists in treating iron in an open-hearth furnace or Bessemer converter having an acid lining and removing silicon and part of the carbon, then skimming the slag from the metal and delivering the metal to a mixer and finally removing it from the mixer and treating it in an electric furnace having a non-oxidizing atmosphere.

967,751. Manufacture and Repair of *India-Rubber Goods*. Thomas Gare, New Brighton, England. Patented August 16, 1910.

967,762. Process of Forming *Fluc from Leather*. Henry G. Halloran, Brighton, Mass. Patented August 16, 1910.

967,777. *Polishing Compound*. Easter M. Hughes and Charles C. Hughes, Highland Park, Ill. Patented August 16, 1910.

967,842. *Anti-Fouling Paint and Varnish*. Walter Schoeller and Walther Schrauth, Berlin, Germany. Patented August 16, 1910.

967,943. Process of Making *Hydrocyanic Acid*. Otto Liebknecht, Frankfort-on-the-Main, Germany. Patented August 16,1910.

967,988. Method of *Unhairing Skins*. William R. Smith, Buffalo, N. Y. Patented August 23, 1910.

967,990. Process of Producing Clear *Stannic Chloride Solutions*. Elmer A. Sperry, Brooklyn, N. Y.

The process consists in adding fuming stannic chloride to a strong aqueous solution of stannic chloride.

967,996. Method of Extracting or *Eliminating Sulphur, Phosphorus*, and Other Impurities from Coal, Ore, Etc. Leland L. Summers, Chicago, Ill. Patented August 23, 1910.

968,013. *Insectifuge Fertilizer for Cotton*. Reuben G. White, Hempstead, Texas. Patented August 23, 1910.

968,203. *Aluminum-Solder*. Joseph Silver, New York, N. Y. Patented August 23, 1910.

968,278. Manufacture of *Wood Pulp*. John C. W. Stanley, Santa Cruz, Cal. Patented August 23, 1910.

968,376. *Pigment*. Arthur Luttringhaus, Ludwigshafen-on-the-Rhine, Germany. Patented August 23, 1910.

968,399. Process of Making *Stable Cyanamide Fertilizers*. Samuel Peacock, Chicago, Ill. August 23, 1910.

968,423. Process for the Manufacture of *Albumose Soap*. Paul Runge, Hamburg, Germany. Patented August 23, 1910.

968,438. Process for the Manufacture of *Bleached Soap*. Fritz Wiedermann, Charlottenburg, Germany. Patented August 23, 1910.

968,509. Process of *Recovering Naphthalene from Gas*. Richard H. Bots, Syracuse, N. Y. Patented August 23, 1910.

968,528. Method of *Generating Oxygen*. Andre Beltzer, Bridgeport, Conn. Patented August 30, 1910.

968,601. Manufacture of *Manganese Steel*. Winfield S. Potter, New York, N. Y. Patented August 30, 1910.

968,758. Process of *Refining Iron*. Josy Flohr, Rodange, Luxemburg. Patented August 30, 1910.

The process consists in treating the molten bath in an open hearth furnace by means of a briquetted mixture containing iron oxide and calcium hydroxide

968,846. *Automatic Gate*. Chester A. Hahn, Collegeview, Neb. Patented August 30, 1910.

968,919. *Explosive Compound*. Joseph Burrows, Port Arthur, Ontario, Canada. Patented August 30, 1910.

The compound comprises 32 parts barium nitrate, 10 parts toluene, 8 parts aluminum.

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WHAT ELECTROCHEMISTRY IS ACCOMPLISHING.*

By JOSEPH W. RICHARDS.

My theme is to depict for you, as clearly as I may be able, the part which electrochemistry is playing in modern industrial processes. I have no exhaustive catalogue of electrochemical processes to present, nor columns of statistics of these industries; but my object will be to classify the various activities of electrochemists and to analyze the scope of the electrochemical industries. And since electrochemical industries have developed in almost all parts of the world except Pittsburg, I will endeavor to bring to your view by means of pictures, taken from actual photographs of plants in operation, the reality and actuality of the large and important electrochemical industries.

SCOPE OF ELECTROCHEMISTRY AND ELECTROMETALLURGY.

Chemistry is the science which investigates the composition of substances, and studies changes of composition and reactions of substances upon each other. As an applied science, it deals chiefly with the working over of crude natural material, and its conversion into more valuable and more useful substances.

Some common examples, to illustrate this statement, are the conversion of native sulphur into sulphuric acid, the manufacture of soda and hydrochloric acid from common salt, the conversion of phosphate rock into super-phosphate fertilizer, etc., etc. Several pages would not suffice to merely catalogue the great variety of chemical industries; immense amounts of capital are invested in them, and they are some of the most fundamental industries in their relation to supplying the needs of a rapidly advancing civilization.

Metallurgy is the art of extracting metals from their ores, and of purifying or refining them to the quality required by the metal-working industries. It is a branch of applied chemistry. The metallurgical industries form a highly important part of our national resources; on them we depend for iron, steel, copper, brass, gold, silver, lead, zinc, aluminum, etc., in fact for all the supply of metals used in arts and industry.

Electrochemistry is the art of applying electrical energy to facilitating the work of the chemist. It is chemistry helped by electricity. It is the use of a new agency in accomplishing chemical operations, and it has not only succeeded in facilitating many of the most difficult and costly of chemical reactions, but it has in many cases supplanted them by quick, simple and direct methods; it has even, in many cases, developed new reactions and produced new materials which are not otherwise capable of being made. A few examples will illustrate these points: Caustic soda and bleaching powder are made from common salt by a series of operations, but the electrical method does this neatly and cheaply in practically one operation; lime and carbon do not react by ordinary chemical processes, but in the electric furnace they react at once to form the valuable and familiar calcium carbide; carbon stays carbon except when the intense heat of the electric furnace converts it into artificial graphite. The list of such operations is a long one, and it may be said that the chemist has become a much more highly efficient and accomplished chemist since he became an electrochemist, and he is becoming more of an electrochemist daily.

Electrometallurgy applies electric energy to facilitating the solution of the problems confronting the metallurgist. Its birth is but recent, yet it has rendered invaluable service; it has made easy some of the most difficult extractions, has produced several of the metals at a small fraction of their former cost, and has put at our disposal in commercial quantities and at practicable prices metals which were formerly unknown or else mere chemical curiosities. It has, further, refined many metals to a degree of purity not previously known. The metallurgist is rapidly appreciating the possibilities of electrometallurgical methods, and they already form a considerable proportion of present metallurgical practice.

Applied electrochemistry, covering in general all of the field just described, is therefore an important part of chemistry and metallurgy, and is rapidly increasing in importance. It is a new art, people are really only beginning to understand its principles and to appreciate its possibilities; it is an art pursued by the most energetic and enterprising chemists, with the assistance of the most skilled electricians. Some of its most prominent exponents are electrical engineers who have been attracted by the vast possibilities opened up by these applications of electricity. The chemists have worked with electricity like children

*An address delivered at the Seventeenth General Meeting of the American Electrochemical Society, in Pittsburg, Pa., May 7, 1910, and printed in the Transactions of the Society.

with a new toy, or a boy with a new machine; they have had the novel experience of seeing what wonders their newly applied agency could accomplish, and it is no exaggeration to say that they have astonished the world—and themselves.

THE AGENTS OF ELECTROCHEMISTRY.

The operating agent in electrochemistry is, of course, electric energy, which may be used in three classes of apparatus, viz.:

(I) Electrolytic Apparatus.
(II) Electric Arcs and Discharges in Gases.
(III) Electric Furnaces.

I. Electrolytic Apparatus.

Electrolytic Apparatus and processes use or utilize the separating or decomposing power of the electric current. Whenever an electric current is sent through a liquid material which is compound in its nature, i. e., a chemical compound, the current tends to decompose the compound into two constituents, appearing respectively at the two points of contact of the electric conducting circuit with the liquid in question, i. e., at the surface or face of contact of the undecomposable conducting part of the circuit with the decomposable part. If the current has a definite direction the constituents appear at definite electrodes. The action is simply the result of the current extracting (or tending to extract) from the electrolyte one of its constituents at each of the two electrode surfaces. All subsequent changes following upon this primary tendency of the current are called secondary reactions, and are practically simultaneous with the primary. These may even be regarded as truly primary reactions also, the primitive decomposing or separating power of the current passing being regarded only as a *tendency* or a *determining cause* which practically results in the reactions actually taking place.

This agency is an extremely vigorous and potent force for producing chemical transformations. It enables us, for instance, to split up some of the strongest chemical compounds into their elementary constituents, to convert cheap materials, in short, to perform easily some very difficult chemical operations and in some cases to perform chemical operations otherwise impossible. A description of all these various processes would take a volume, but a short explanation of a few of them will make the principles clear and suffice for my present purpose.

Electrolysis of Water: As a raw material, water may be said to cost nothing. Apply an electric current to it in the proper way, and it is resolved into its constituent gases, hydrogen and oxygen, as cleanly and perfectly as anyone could desire. These gases have many and various uses, and are valued each at several cents per pound. A whole industry has thus grown up, based on the simple electrolysis of water, to supply these two gases for various industrial uses. Europe possesses many of these plants; there are a few in the United States. The speaker has translated from the German a small treatise on this industry.

Electrolysis of Salt: Common salt, sodium chloride, is one of the cheapest of natural chemicals. It has some uses of its own, but centuries ago chemists and even alchemists devised chemical processes for transforming it into other sodium salts, such as caustic soda or soda lye for use in soap, soda ash or carbonate, for washing or glassmaking, and into chlorine bleaching materials. Chemical works operating these rather complicated chemical processes exist on an immense scale in all civilized countries; it is estimated that $50,000,000 is thus invested in Great Britain alone. The electrolytic alkali industry is barely twenty years old, yet it is already more than holding its own with the older chemical process, and advancing rapidly; twenty years more will probably see the older processes entirely superseded—they are at present fighting for their existence. As for the electrolytic process, the salt is simply dissolved in water and by the action of the current converted into caustic soda at one electrode and chlorine gas at the other. By some special devices these are kept separate and collected by themselves, and the work is done. The principles involved are simplicity itself as compared with the older chemical processes, the only agent consumed is electric energy, and the products are clean and pure.

Chlorates: These are salts used on matches and in gunpowder. Chlorate of potassium is a valuable salt with important uses. It is made from common cheap potassium chloride, in solution in water, by simply electrolyzing the solution without trying to separate the products forming at the electrodes. It is a simpler operation than the production of electrolytic alkali. Chlorate thus forms in the warm solution, and is obtained by letting the solution cool and the chlorate crystallize out. The ordinary chemical manufacture of this salt was tedious and dangerous; the electrolytic method has practically entirely superseded it.

Perchlorates: These salts have more limited uses, but are made by expensive chemical methods. The electrolysis of a chlorate solution at a low temperature, without separating the products formed at the two electrodes, results in the direct and easy production of perchlorates. I cite this more to illustrate what I might call the versatility of electrochemical methods, rather than because of its commercial importance.

Metallic Sodium: The caustic soda produced from salt can itself be eletrolytically decomposed; this is the easiest way of producing metallic sodium. Sir Humphry Davy discovered sodium by electrolyzing melted caustic soda, and at this moment several large works are working his method on an immense scale. The caustic contains sodium, hydrogen, and oxygen, and the current simply liberates the sodium as a molten metal and frees the other two as gases, which escape into the air. The process is simplicity itself—when the exact conditions are known and rigidly adhered to. Metallic sodium is a very useful material to the chemist, and the electrolytic method produces it at probably

one-fourth the cost of making it in any purely chemical way.

Magnesium: This is a wonderfully light metal, whose chief use is in flash-light powders. Its compounds are abundant in nature, but its manufacture by any other than the electrolytic method is almost impracticable. The operation consists in simply passing the decomposing current through a fused magnesium salt—a chloride of magnesium and potassium found in abundance in Germany.

Aluminium: The most useful of the light metals; an element more abundant in nature than iron, yet which costs by chemical methods at least $1.00 per pound to produce; electrochemistry enables the makers to sell it at a profit at $0.25 per pound. This is probably the most useful metal given to the world by electrochemistry. Although the French chemist Deville obtained it by an electrolytic method in 1855, yet he had only the battery as a source of electric current, and the process was too costly. This very city of Pittsburg was the real cradle of the electrolytic manufacture of aluminium, when, in 1889, Mr. Chas. M. Hall, with the financial assistance of the Mellons and the business assistance of Captain A. E. Hunt, commenced to work his process up at 33d street on the "West Side." The principle of the process is here again one of beautiful simplicity—when it is once made known. Aluminium oxide, abundant in nature, is infusible in ordinary furnaces, but easily melts and dissolves, like sugar in water, in certain very stable and liquid fused salts—double fluorides of aluminium and the alkali metals. On passing the electric current through this bath, the dissolved aluminium oxide is decomposed, appearing at the two electrodes as aluminium and oxygen respectively. When all the oxide is thus broken up, more is added, and the operation continues. One of the most difficult problems of ordinary chemistry is thus simply, neatly and effectively solved by electrochemistry. The lower cost of power at Niagara Falls drew the industry away from Pittsburg, in 1893, and it is now run on an immense scale at several places where water power is cheap and abundant. Mechanical power is, however, being produced cheaper every year; gas engines have halved the cost of such power, steam turbines on exhaust steam may even do better; there is no inherent impossibility in the return of the aluminium industry to the Pittsburg district. Many other factors besides cost of power bear on the question; cost of labor, abundance of labor, cost of carbon, coal for heating, various supplies, railroad freights, nearness to the consumers, and many other considerations must be taken into account. Aluminium is certainly destined to become the most important metal next to iron and steel, and, as far as one can now foresee, will always be produced electrochemically. To have accomplished the establishment of this one single industry, would itself have proved the usefulness of electrical methods and their importance to chemistry and metallurgy.

Refining of Metals: Unless metals are of high purity they are usually of very little usefulness. Electrolytic methods enable almost perfect purity to be easily attained, and in addition permit the separation at the same time of the valuable gold and silver contained in small amount in the baser metals. Over $100,000,000 worth of copper is electrically refined every year in the United States; the metal produced is purer than can be otherwise obtained, giving the electrical engineer the highest grade of conducting metal, while several million dollars' worth of gold and silver are recovered which would otherwise have to be allowed to remain in the copper. Again, the method is so simple that but a few words are necessary to set it forth in principle. The impure copper is used as one electrode—the anode—in a solution of copper sulphate containing some sulphuric acid; the receiving electrode—the cathode—is a thin sheet of pure copper, or of lead, greased. The electric action causes pure copper only to deposit upon the cathode, if a properly regulated current is used, while a corresponding amount of metal is dissolved from the anode. Silver, gold and platinum are undissolved, and remain as mud or sediment in the bottom of the bath; other impurities may go into the solution, but are not deposited on the cathode if the current is kept low. The cost of this operation is small, and the results are so highly satisfactory that 90 per cent of all the copper produced is thus refined. Similar methods are in use for refining other metals, silver, gold and lead are thus refined on a large scale; antimony, bismuth, tin, platinum, zinc and even iron can be thus refined; the field is very inviting to the experimenter and to the technologist, and is rapidly increasing in industrial importance.

Metal Plating: All electro-plating is done by the use of electrolytic methods similar to those just described. If we imagine the impure metal anode replaced by pure metal, and the receiving cathode to be the object to be electro-plated, we have before us the electro-plating bath ready for action. Everybody knows the value and use of gold, silver and nickel plating; less well known are platinum, cadmium, chromium, zinc, brass and bronze plating. These are among the oldest of the electrochemical industries Electrotyping is only a variation of this work; also the electrolytic reproduction of medals, engravings, cuts, etc., and even the production of metallic articles of various and complicated forms, such as tubes, needles, mirrors, vases, statues, etc. There is opportunity here to hardly more than catalogue these various branches of electrometallurgical activity. Pittsburg people will be interested, however, in knowing that many of the newer buildings in this city contain thousands of feet of electrical conduits zinc plated in splendid fashion by electrolysis, at a works within a few miles of this city. At McKeesport tubes are coated by dipping into melted zinc, on an immense scale, but the electrolytic method is gaining a foothold, and we may live to see all galvanizing in reality practised as it is spelled. The removing of metallic tin from waste tin scrap is also accomplished on a large scale by

the application of similar principles. It is being operated at a distance from Pittsburg, but your open-hearth furnaces use up annually thousands of tons of the scrap steel thus cleaned and saved for re-manufacture into useful shape.

Without having mentioned or described more than a fraction of the electrolytic methods in actual industrial use, I hope that I have made clear the importance and extent of this kind of electrochemical processes. Assuming this, we will pass to the consideration of another, entirely different and yet important, class of apparatus and processes.

II. ELECTRIC ARCS AND DISCHARGES IN GASES.

Electric Arcs and high-tension discharges through gases are capable of producing some chemical compositions and decompositions which are very useful, and profitable to operate. This is a branch of electrochemistry which has not been as thoroughly studied as some others, its phenomena are not as thoroughly under control as electrolysis and electro-thermal reactions, and its possibilities are not as thoroughly understood or utilized.

Ozone is being made from air by the silent discharge of high-tension electric current. The apparatus is so far simplified as to be made in small units suitable for household use, ready to attach to a low-tension alternating current supply. The uses for the ozone thus produced are particularly for purifying water and air; it makes very impure water perfectly safe to drink, and purifies the air of assembly halls and sick-rooms, acting as an antiseptic. According to all appearances, this electrochemical doubling up of oxygen into a more efficient oxidizing form is developing into a simple and highly efficient aid to healthy living.

Nitric acid is an expensive acid made from the natural alkaline nitrate salts, such as Chili saltpeter. These nitrates are the salvation of the agriculturist, for they furnish the ground with the necessary nitrogen which plants can assimilate. The Chili "nitrate kings" have gained many millions of dollars, even hundreds of millions, in thus supplying the world's demand for fertilizer. But, electrochemistry has another solution to this problem, which is rapidly rendering every country which adopts it independent of the foreign fertilizer. The air we breathe contains uncombined nitrogen and oxygen gases, which if combined and brought into contact with water furnish the exact constituents of nitric acid. The way to do this has been laboriously worked out, and the electric arc is the agent which does it. Air is simply blown into the electric arc, where it for an instant partakes of the enormous temperature, and on leaving the arc is cooled as quickly as possible. In the arc, the combination of nitrogen and oxygen is effected to a certain extent, and the mixture is cooled so suddenly that it does not find time to disunite. The nitrogen oxides thus obtained are drawn through water, and this solution of nitric acid is run upon soda, to produce sodium nitrate, or on lime to produce calcium nitrate, the latter called Nitro-lime or "Norwegian saltpeter." These salts entirely replace the South American natural salt.

The materials used in this industry are air and lime, and to these is added electrical energy. Air is universal, lime cheap almost everywhere, and electrical energy is cheapest where water powers are most abundant. In Norway, water power can be developed and electrical energy supplied from it at a total cost of $4.00 to $8.00 per horsepower-year. Some other countries can do nearly as well. Under these conditions, almost every country can afford to make its own nitrates, and so be independent of other countries for the fertilizer needed in peace and the gunpowder used in war. Norway felicitates itself already on being thus independent; nearly 200,000 horsepower is being utilized there by a $15,000,000 syndicate, and the industry is spreading rapidly over Europe. The study of this problem, its solution, and the rapid development of this vigorous industry, is one of the most remarkable chapters in the history of recent industrial development. In this accomplishment, electrochemistry has signally aided the agriculturist, and demonstrably multiplied the food-supply resources of all civilized and highly-populated countries.

Boron is an element which has until recently defied the best efforts of chemists to isolate in a pure state. It is an element which may have important application in the manufacture of a high-class special steel—boron steel. Dr. Weintraub, one of our fellow members, has recently solved the problem of its production by an adaptation of the "oxygen-nitrogen" arc apparatus, and utilizing the same principle of introducing the material into the arc and very rapidly cooling the products obtained. We mention this not because of its great commercial importance at present, but because it shows how the "arc method" may be of wide application in solving other difficult chemical problems; it has opened before us a new method in chemical science, and may give birth to many and various new chemical industries.

III. ELECTRIC FURNACES.

Electric furnaces are furnaces in which the necessary heat or degree of temperature is produced or attained by means of electrical energy. The electric current is used in these furnaces solely for its heating or thermal effect, and either alternating or direct current may be used, but alternating is preferred because of its easier generation and management, capability of being procured from transformers, and absence of electrolytic effects.

Electric furnaces render remarkable and highly valuable service to the chemist and metallurgist, for two distinct and unique capabilities; they can generate heat within themselves without the use of combustion and the consequent products of combustion to complicate the working of the furnace, and they can besides, if desirable, produce temperatures absolutely unapproachable in furnaces using fuel, and thereby enable the carrying out of operations only possible at these

extremely high temperatures. The upper limit of electric furnace temperature is simply the volatilizing point of carbon, the temperature at which the material of which the lining of the furnace is made, is boiled away. This is about 3700° Centigrade or 6700° Fahrenheit. The simple statement that this is 3 times as high as the melting point of cast-iron, may give some notion of the enormous temperature here at one's command. Besides high temperature, the efficiency of application of electrical heat to the useful purpose is usually high, in many cases 50 to 75 per cent of all the heat developed can be usefully applied, as against 5 to 50 per cent utilized in fuel-fired furnaces. The heating value or thermal equivalent of the electric current is perfectly definitely known; one kilowatt-hour will furnish 860 calories (3400 B. t. u.), which if applied usefully at 100 per cent efficiency would bring to boiling and convert into steam 1.35 kilograms (3 pounds) of water, or bring to melting and melt about 3 kg. (7.5 lbs.) of cast-iron, or 2.5 kg. (5.5 lbs.) of steel.

Artificial graphite is a product particularly electrochemical in its manufacture. Your fellow-townsman, Dr. E. G. Acheson, has practically created this industry and his name sticks to the product—Acheson Graphite. No temperature but that of the electric furnace can convert the ordinary amorphous carbon, containing small amounts of foreign substances, into pure, soft, homogeneous, unctuous graphite. The purity of the product and its quality has even surpassed the artifice of Mother Nature herself. Whereas before, graphite in small scales was laboriously gathered from Ceylon and Siberia, and with great pains worked up into graphite articles, now the articles are simply molded in ordinary impure amorphous carbon, and converted through and through, retaining their shape, into finished and complete graphite articles. What this highly pure product is going to do for lubrication, for annihilating the friction of the world's machinery, perhaps only a few suspect and only Mr. Acheson knows. You will all know more about this soon, and everyone of you who uses machinery will profit by it. Meanwhile, in another direction, probably half the electrochemical industries now operating are beneficiaries of this invention, using artificial graphite anodes in electrolytic operations or as electrodes in electric furnaces. The electrochemical industry in general has been most wonderfully helped by this one electrochemical process.

Carborundum stands for a large industry, centered at Niagara Falls, and founded also by Mr. Acheson. Twenty years ago the name was not in the dictionary; now it is known all over the world as the most efficient abrasive material in use. First produced just across the Monongahela, in a little furnace as large as a cigar box, and sold for polishing diamonds at many dollars per ounce, it is now made by tons in electric furnaces of 2,000 horsepower capacity, and competes successfully with such common natural abrasives as emery and common sand. And in fact, common silica sand, the most abundant material on earth, with common carbon, like coke, furnish all the ingredients necessary for the furnace to work upon to produce SiC, silicon carbide. Mr. Acheson not merely founded another new industry, but he discovered a new chemical compound; he has enriched science, promoted industry and created new instruments of service; no wonder that his scientific friends have showered on him honors,—the Rumford Medal, the Perkin Medal, and two years ago the presidency of this Electrochemical Society.

Silicon is the metal whose oxide is silica sand, and is by far the most abundant metallic element on earth. Up until very recently it was to be seen only in chemical museums, costly and useless—a chemical curiosity. Now Mr. F. J. Tone, one of Mr. Acheson's former lieutenants, is producing it by the ton and selling it by the carload, at a few cents per pound. The chemical world has found uses for it, large uses, such as in solidifying steel, making good copper castings, reducing other metals from their oxides, chemical "pots and pans," etc. This illustrates again the variety of the achievements of electrochemistry. Here is a new material furnished the world at a low price and all sorts of workers are finding all sorts of advantageous uses for it. The electric furnace makes it from simply sand and carbon, with electric energy, and plus considerable "brains."

Calcium Carbide is the product of another American invention. The name was scarcely in the chemical books, and the purveyors of the rarest chemicals did not have it on their lists, when Mr. Thomas Willson, trying to make something else in the electric furnace, made this compound from ordinary lime and carbon, and started an electrochemical industry which has spread all over the civilized world. I am almost tempted to say that there is a calcium carbide works everywhere but in Pittsburg, but that would really be an exaggeration, and I will not say it. The best thing about calcium carbide is that it is easy to make; the raw materials may be found almost everywhere, and wherever power is cheap a flourishing calcium carbide industry may be built up. The curious thing about it is that its chief use is based on destroying it, acting upon it by water and forming acetylene gas. How great a boon acetylene gas has been to the bicyclist, automobilist, for lighting trains, isolated houses, stations and towns, needs no recital before this audience; but the value of acetylene as a means of welding with the blowpipe is only commencing to be appreciated. Acetylene welding is a convenience which owes its existence entirely to the electrochemical production of calcium carbide, and the iron and steel and other metal industries are being greatly helped by its use.

Titanium carbide is not as familiar as calcium carbide. It is made in a manner similar to the production of carborundum, using titanium oxide (rutile) and carbon. It has no uses similar to calcium carbide, nor

any like silicon carbide. But electrical engineers have discovered that as arc light tips or electrodes it gives the most efficient arc light yet discovered, with a light efficiency running up to 3 candlepower per watt of electrical energy. This is probably 50 per cent of the theoretically possible conversion of electrical energy into light energy, and is doubly as efficient as has ever before been attained. What this means for street lighting everywhere is difficult to realize; perhaps the best and most easily understood comparison is to say that the titanium carbide arc lamp is to the ordinary arc, as the tungsten filament incandescent lamp is to the carbon filament lamp; you will all grasp the scope of that statement. With acetylene lighting on one hand, and titanium arc lighting on the other, we need say no more about the influence of electrochemistry on modern illumination.

Phosphorus. I stated before that the potassium chlorate on safety matches was all being made electrochemically. We can say practically the same of phosphorus. The electric furnace enables us to distill phosphorus much more easily and safely from the natural phosphates, than the older chemical methods. Calcium carbide gives us acetylene gas, and another electrochemical furnace gives us the phosphorus to "strike the light."

Ferro-alloys are alloys of iron with the more expensive metals, used in manufacturing steels of various kinds. Ferro-manganese is used in practically all steel, ferro-silicon is used in almost all. Ferro-chromium,—nickel, — tungsten, — molybdenum, — boron, — uranium,—vanadium are some of the alloys used to make the special alloy steels, such as find great use in rapid tool steel, automobile axles, armor-plate, gun-steel, etc. These alloys are of great importance to the steel industry, and are made almost exclusively in electric furnaces. The industry has flourished most in countries having cheap power, such as among the French Alps, and the importations into this country have been on a large scale. Fortunately, we are commencing at Niagara Falls, in Virginia and in Canada, to supply ourselves with these necessities of the steel industry, and we may look forward to a steady and large domestic development of this industry. Within a few miles of this hall, a small electric furnace is now at work making ferro-tungsten to go into high class, expensive steel. Pittsburgh is going to take its share in the running of this particular electro-metallurgical industry.

Pig-iron would seem to be about the last item to find a place in an address upon the electrochemical industries. But the truth must "out":—electric furnace pig-iron is now being made, and made and sold at a profit. We will hasten to admit that the furnaces are small, that they are in California and Sweden, where fuel is expensive and power is cheap, that a great deal of money has been sunk in bringing them to their present condition; but after all has been admitted, the fact remains that electric furnace production of pig-iron is not a chimera, but an accomplished fact. Pittsburgh has been able to boast that she "could manufacture a ton of pig-iron and put it down anywhere in the world cheaper than it could be there produced." That may be *still* true *of the kind* of pig-iron which Pittsburgh is able to make, but there are grades and qualities of pig-iron (Swedish charcoal pig-iron, for instance) which are still imported into this country and sold at double the price of our domestic pig-iron. And, in the country where that charcoal pig is slowly, laboriously and skillfully made, the electric shaft furnace is able to compete with the charcoal blast furnace in producing this high quality pig-iron. Dr. Haanel, of the Canadian Department of Mines, has in a recent report given us the most reliable information about the running of this furnace. The construction is peculiar, and still somewhat experimental, the full power for which the furnace was designed has not yet been available for running it, the workmen are new to their tasks, the overseers are still learning, the irregularities in the running are not yet all overcome, and many of the minor details are yet being adjusted. The furnace is still, in brief, decidedly in the formative or experimental stage. Yet, notwithstanding, Professor Odelstjerna, one of the most expert of Swedish metallurgists, states that the cost of production is $1.50 per ton less than in the Swedish blast-furnaces. If that is true now, it needs little gift of prophecy to figure out at least $2.50 per ton saving when the furnace is properly run. Three similar furnaces of greater capacity, 2,500 kilowatts each, are to be erected in Norway; three similar ones are to be put up at Sault Ste. Marie, Canada. These are only the forerunners, we may be sure, of dozens or perhaps even hundreds which will be built and operated within the lifetime of most of this audience. The time at our disposal forbids me describing these interesting furnaces; I can only refer you to Dr. Haanel's interesting reports and to the transactions of this Society, particularly to our Volume XV. One surmise of my own I will, however, take time to mention: I have predicted that this electric furnace pig-iron, made without the admittance or use of air blast, will be far superior to ordinary pig-iron for conversion into steel, because of the absence of oxygen or, particularly, of nitrogen. *Time* will test this prediction, too.

Electric Steel is at present a topic of absorbing interest and great potentialities. It was primarily a competitor of the most expensive kind of steel—crucible steel. It was first made commercially in 1900, by Mr. F. A. Kjellin of Sweden, by melting together in an electric furnace the same high grade materials which are usually melted down in crucibles to form crucible steel. The product was made equal in quality to crucible steel, it was produced in lots of a ton or more at a melt, of very satisfactory uniformity, and with cheap water power to furnish electricity the cost was considerably below that of crucible steel.

The steel melting pot or crucible is a siliceous vessel, holding about 100 pounds of steel, lasting only a few

heats, and lifted in and out of the furnace by manual labor. The consumption of fuel to get the required melting heat is wickedly wasteful; not over five per cent of the heat-developing power of the fuel used is efficiently utilized as heat in the melted steel, and the actual proportion is usually less than half that much. The cost of labor, crucibles and fuel is excessive, and to this must be added the high cost of the pure material which must be used—practically the purest iron which can be made.

The electric furnace is changing all this, rapidly in continental Europe, slower in Sheffield, and still lower in America; but the change is spreading surely and inevitably. Real crucible steel will soon be a thing of the past, supplanted entirely by electric furnace steel of equal quality, made and sold much more cheaply.

The electric furnaces used are of almost all types. The induction furnace was developed commercially by Kjellin in Sweden, improved, enlarged and greatly developed by his associates in Germany, combined with the Colby pattern in America, and still further modified by Hiorth in Norway. Thirty-six of these furnaces, the maximum capacity being one at Krupp's works at Essen, 8½ tons at a charge, are now built or building. The American Electric Furnace Co. is organized to push their building and operation in America. The arc radiation furnace was developed by Major Stassano, an Italian artillery officer. It melts by heat radiated from powerful electric arcs. Several of these are in operation in Europe, and a gentleman managing one of the large American steel companies, who has just returned from an inspection of the different electric steel furnaces operating in Europe, tells me that he considered the Stassano furnace as doing the best work all around, of all the furnaces he saw in operation. I have seen this furnace operating smoothly and regularly, in Turin, producing steel for castings which were being sold in competition with open-hearth and Bessemer steel castings in the open market. The single arc furnace is best illustrated by the Girod furnace, which is built like the body of an open-hearth furnace with the electric current entering the bath by carbon electrodes suspended above it, and springing arcs to it, while the current leaves the bath through metallic conductors passing through the saucer-shaped hearth below the level of the metallic surface. These furnaces work with great regularity, and a large number are operating in Europe in capacities up to 12 tons each. I am informed that the Krupp Works at Essen has just contracted to put in five of these of the 12-ton size, which would confirm statements made to me by my European friends that this furnace is working the best of all the electric steel furnaces now operating in Europe. The double arc furnace, of which the Heroult furnace is the most familiar type, works with two arcs in series, the current entering the bath and leaving it also through electrodes suspended above it. The general style is that of an open-hearth furnace with electrodes passing through the roof. The current used is roughly 100 kilowatts per ton of steel capacity, and the largest so far operated is 15 tons. A three ton furnace of this type was seen by you at the Firth-Stirling Steel Works at Demmler, yesterday, producing crucible-quality steel. The U. S. Steel Corporation has acquired licenses to operate the Heroult furnace, and has already two 15-ton furnaces in operation. Without doubt, the Heroult furnace is at the present time the most popular and successful electric steel furnace in the United States. I have not time to more than name the Keller, the Hiorth, the Harmet, the Frick—all of which are operating at this present moment, in Europe.

There are other ways of making steel than the crucible method. Bessemer steel is the cheapest, and open-hearth steel is next best. These two varieties grade into each other in quality, but between open-hearth and crucible steel there is an enormous gap in price and in quality which is destined to be bridged over by intermediate qualities of electric steel, as it becomes cheaper and is manufactured on a larger scale. This will soon become one of the large uses of the electric method, occupying a field peculiarly its own. It will enable steel manufacturers to supply steel better than the best open-hearth product at less than the price of crucible steel. I need not enlarge upon the advantages of this, to a Pittsburg audience.

There are also varieties of methods of manufacture of steel, aside from the melting together of highly pure materials as in the crucible method, which are equally available in most types of the electric furnace. The Bessemer converter takes liquid pig-iron as it comes from the blast-furnace and by rapid oxidation by air blast converts it into steel. Mr. Heroult has tried to combine the Bessemer converter with the electric furnace, in one apparatus, the idea being to first oxidize the metal by air blast and then to finish it while electric current supplied the necessary heat. I have no information that this combination furnace is anywhere in successful operation, but the equivalent of the same operation performed first in the Bessemer converter and then on the blown metal transferred into an electric furnace for finishing, is already in regular commercial operation at the South Chicago Works of the U. S. Steel Corporation. I have had the privilege and pleasure, thanks to Mr. Heroult, of studying that operation, in company with Mr. Heroult and the editor of *Metallurgical and Chemical Engineering*. You may find a description of the process in the April number of that journal, so I will not repeat it here—except so far as to say that 15 tons of the product of the Bessemer blow, oxidized to the extent usual in the Bessemer converter, was kept melted less than two hours on the basic hearth of the electric furnace, treated with two different slags to refine it from phosphorus and sulfur, de-oxidized or "dead-melted," and then poured into ingots of steel intended for axles. The steel produced was of better quality than the usual cor-

responding open-hearth metal, and was produced at slightly *less* total cost. This combination process bids fair to give a new lease of life to the declining Bessemer steel industry; its economic importance will appeal particularly to this audience.

The open-hearth steel furnace is, at present, the most important of the methods of manufacturing steel—"tonnage steel." It makes steel from pig-iron and scrap of proper quality, or from pig-iron and iron ore (mill-scale), or from pig, scrap and ore. It makes its best steel on silica hearths from high grade material low in sulfur and phosphorus, and its cheapest steel on basic hearths from almost anything. The electric furnace can do any or all of these things, and, as a general proposition, produce better steel from given materials than the open-hearth furnace. Under what circumstances it will pay to use the electric furnace instead of the open-hearth furnace would take at least one lecture to discuss; we will not go deeply into it here. In Europe, countries which have very cheap water power, around $10 per horse-power year, and fuel costing $4 to $6 per ton, are finding the electric furnace the cheaper; with power costing $20 and coal $5, the two are about on equal terms; in Pittsburgh, with power at $30 and coal at $1.00, the open-hearth furnace is by far the cheaper, for producing such steel as it can produce. However, even here, the combination of Bessemer and electric furnace is possibly cheaper than the all open-hearth process; the combination of open-hearth and electric furnace process is quite possible and practicable, to produce crucible-quality steel on a large (tonnage) scale, and the combination of the open-hearth and electric furnace into one furnace is not only a possible combination, but is actually being "tried out." The latter idea is to take an open-hearth furnace, and to place electrodes in the roof. The furnace is run as an ordinary open-hearth furnace, with the electrodes withdrawn; and at the close of the open-hearth heat, gas and air are shut off entirely, the electrodes lowered into proximity to the bath, and the heat finished as an electric furnace heat. The idea is sound and practicable, and will result in the production of better steel than can be obtained from any open-hearth furnace, at but a slight advance on the cost of the open-hearth steel, say $2.00 to $3.00 per ton.

As to the capacity for enlargement of electric steel furnaces, they started out to duplicate the crucible steel process, producing 100 lbs. of melted steel at a heat, and in eight years have risen to 15 tons capacity. In Europe, an electric calcium carbide furnace of 18,000 kilowatts, capable of producing 200 tons of carbide daily, is in practical operation. A furnace of like power capacity could be built to make steel, and would be a 200-ton steel furnace or larger. We can therefore say with assurance, that with a little more experience and experiment, electrometallurgists will be able to furnish the steel maker with electric steel furnaces as large as are wanted—up to 200 tons' capacity if desired.

CHEMISTRY IN THE BUREAU OF STANDARDS.*

By W. F. HILLEBRAND, CHIEF CHEMIST.

I have felt impelled to speak on the subject "Chemistry in the Bureau of Standards," for the reason, mainly, that since my connection with that Bureau little published evidence of chemical activity has been offered. The impression might arise and spread that proper advantage is not taken of the opportunities provided. It is my wish to forestall such an opinion. That the public closely interested in chemistry has a right to feel interested in the subject goes without saying, for the Bureau is a Federal institution where work is expected to be directed chiefly toward providing the public with authentic information on a variety of subjects. This information must be of value for the most part to the industries, otherwise the Bureau fails in its chief function. From its inception the Bureau has endeavored to meet the most insistent demands upon its reservoir of physical knowledge and at an increasing rate as facilities were given it for so doing. That it has been in the main eminently successful in this respect is sufficiently attested by the support it has at all times received from Congress and by the marked growth it has experienced and is experiencing, a growth that would be impossible without strong backing, that is, the approval of an influential section of the community both industrial and educational, manifested through its representatives in the national capitol.

The growth of the chemical side of the Bureau has been slow, but it is now increasing rapidly at a rate which bids fair to call for a special building within a couple of years. At the start it was not clear, apparently, along what lines the chemical work of the Bureau might best develop and I was myself in doubt for some time.

The view point of my predecessor, Dr. Noyes, that research without direct practical bearing should not be elbowed out of view by the demands of the industries, is one that should need no defense before a gathering of this character. It is a view that is held by the Director of the Bureau as well as by myself. Nevertheless, during the interval between the withdrawel of Dr. Noyes from the Bureau and my own transfer to it, the work of the small chemical force was wholly along practical lines. The demands of one and another of the Government Bureaus and Departments for help in the preparation of specifications for materials in which they were vitally interested had become insistent. Dr. Stokes, the associate chemist in charge, was deeply impressed with the importance of the numerous problems presented and devoted himself with ardor and great ability to their solution. He had mapped out extensive lines of investigation and had initiated several different researches of a most difficult nature. Unfortunately his withdrawal from

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the bureau has hindered the prosecution of much of this work for lack of a directing spirit with full comprehension of the subject in its different bearings. At the same time, it was felt, in view of the obscurity in which some of the questions were involved and the length of time needed for their study and the uncertainty of a successful issue, that our chief attention should be centered for the present on other lines of work where success was practically assured and the immediate value to the community was plainly evident.

The most important of these problems was a great extension of one already initiated under Dr. Noyes, namely, the providing of carefully analyzed materials by which chemists can check the accuracy of their analytical methods and employers can control the work of their employes. The usefulness of these materials is not confined to those employed in the industries but extends equally to educational institutions. To you, being chemists, it is hardly necessary to offer any arguments in support of the use of such standardized materials. The subject is treated briefly but with sufficient fullness in a publication which has been issued only very recently as a circular of information regarding the samples that have been provided thus far by the bureau or are in immediate preparation, some 37 in all. The number will be very largely added to for there is an ever increasing demand in this direction, and I feel that the bureau can do no greater service to chemists of the industries at present than by catering to this demand. Not only will benefit result from the use of the samples themselves but also from the experience that the bureau chemists will gain, and have already gained in their close study of the methods employed in analyzing them. To this feature I will revert later.

The list of samples in stock comprises 3 pig irons, 5 Bessemer steels, 5 basis open hearth steels, 6 acid open hearth steels, and 1 vanadium steel, to which will be added, as soon as analyses can be made, a nickel steel, a chrome-vanadium steel, and a chrome-tungsten steel. Of ores there are an argillaceous limestone, suitable for the manufacture of Portland cement, a zinc ore, and 3 iron ores from the Lake Superior region. It is impossible to find any single ore from this region that can advantageously be used as a standard for all the constituents that are ordinarily determined in an iron ore. Hence, the multiplication, one being used for iron, phosphorus and silica, the second for alumina, lime and magnesia, and third for manganese. A titaniferous iron ore from New Jersey is in process of analysis, and it is proposed to provide later one typical ore from the Alabama region. Possibly typical ores of lead and zinc from the Rocky Mountain region will follow.

It is to be said here, however, that the selection of ores that can be advantageously used as standards for analysis offers far greater difficulty than that of alloys, for the reason that they are almost always so subject to changes in moisture content from day to day or at different altitudes, as to detract very much from their value. If their sensitiveness to hygrometric variations is at all pronounced it is almost hopeless to expect that all chemists will be able to reduce them to a fixed water content, no matter how precisely formulated may be the directions for drying. The moisture content may vary somewhat without detriment so far as the minor constituents are concerned, but not so for those present in large amounts.

We have also a pure sugar for use as a standard in calorimetric and saccharimetric work, and studies are in progress looking to the applicability of other standards for the measurement of heat of combustion, such as benzoic, salicylic, phthalic and hippuric acids, naphthalene, anthracene and camphor. This work is done in co-operation with the heat division of the bureau.

The American Brass Foundrymen's Association has enlisted our aid in the preparation of standard brasses and bronzes, and a beginning has been made with two brasses, which are in preparation.

We have undertaken to aid the fertilizer interests by carefully analyzing one or more typical phosphate rocks and by testing at the same time the relative values of the different methods in common use, especially with respect to the influence on them of such interfering constituents as are common to materials of this class—pyrite, fluorine and organic matter.

I could easily devote an hour to the problems encountered in the selection and preparation of the samples themselves and several more to those connected with their analysis. An enormous volume of correspondence on these points has accumulated. We endeavor to keep in close touch with prominent manufacturers and especially with prominent chemists soliciting their advice and criticism. Almost without exception our efforts have met with hearty approval and support.

It may be well to introduce here some remarks relative to the plan we have hitherto followed in obtaining the composition of our samples. It is a plan of co-operation, in which leading works chemists and commercial chemists are invited to participate. The almost inevitable result is failure of satisfactory agreement in the reported results. Ordinarily we have given opportunity to those whose results differed markedly from the mean to revise their work without indicating to them the direction or magnitude of the deviation. This course has often resulted in much loss of time and necessitated much correspondence. For certain cases, and eventually perhaps in all, the bureau may decide to depend solely on its own chemists to establish the composition of a given material, but for some time to come this plan will be employed to a limited extent only. The bureau must first afford to its analysts sufficient time to become masters in their particular fields to an extent that will command general confidence. Until this condition is fulfilled it is far better policy to share the responsibility with

experts outside of the bureau. The certificates which the bureau issues with its analyzed samples represent, therefore, the best efforts of a considerable number of analysts who are supposed to be especially expert in the anlysis of the given material, and the mean undoubtedly gives in most cases a close approximation to the correct composition. The bureau does not, however, undertake to vouch for their correctness. The results by different analysts and by different methods are reported in such a way that the person using them can see at a glance what variations are to be expected in commercial work done by supposed experts and under conditions that are presumably the best that are to be encountered in commercial laboratories.

In certain cases, such as pig iron and the ordinary steels, the methods commonly used and the precautions observed are of the highest known order. The commercial results on the average are, therefore, to be accorded fully as great weight as those obtained in the bureau. It is not always so with other materials, when the character of the reagents or the apparatus play a more important part, and when the complexity of composition, as in ores, introduces special difficulties in the way of effecting complete separation of the constituents and their accurate determination. In special cases the bureau regards its own values as closer to the truth than the mean of any number of outside determinations. This is true, for instance, of the alumina and mangnesia in one of the Lake Superior iron ores and even in the value for iron itself in another of them.

One without experience can form little idea of the difficulties and delays that have been encountered, from the initial selection of one of our samples through the machining, grinding, mixing, analyzing, and assembling of data to its final issuing. It took us nearly a year to get the bars to replace one of our steels of which the supply gave out. The steel company that undertook to fill the order had to make five castings before a product of the right composition was obtained. Once delivered to the bureau it takes from two to three weeks to reduce the sample of steel or iron to fine chips. These sometimes have to be ground finer in a special machine, and in any case must be most thoroughly mixed. The successful mixing of 300 or 400 lbs. of such a material requires a special mechanical mixer and no one of those on the market is entirely satisfactory. The one we have used we modified materially and are now having one made that works on a different principle entirely.

We have experimented somewhat with a view to securing homogeneous samples of relatively low melting alloys and metals in a state of sufficient division, without the use of a lathe, and have some hopes of eventual success.

Much time has to be expended by us in analyzing these materials particularly the ores, brasses and special steels, for which the commercial methods are either more or less inadequate or have not received the extensive study and testing given to those for irons and plain steels. It is to be borne in mind that we must not be contented with a single determination or with a few determinations by a single method, but that our problem is to ascertain just as closely as is possible the true composition of these complex materials. Literally months of time may thus be consumed in the study of a single sample of a new kind. The knowledge thus gained, however, shortens by far the time required for later analysis of similar or related samples. In acquiring this knowledge and in testing the various commercial methods against each other, we have already made useful observations that will be of value to others as well as to ourselves. We shall not hasten to publish our observations, but wait until we have had full opportunity to verify them repeatedly. Much information on certain of our own methods and in less degree on those used by others is to be found in our recently issued circular—"Methods of Analysis for Iron and Manganese Ores."

In addition to the above, we have taken the preliminary steps looking toward the issuance by the Bureau of a sodium oxalate for the standardization of solutions to be used not only in oxidimetry, but in acidimetry as well. Our reasons for making choice of sodium oxalate I need hardly go into now, save to say that for oxidimetry it seems to be the most satisfactory material that can be had in considerable quantity. When pure (and the different makes on the market are not to be taken at their face value, but must be tested by each buyer) the article is stable and eminently satisfactory as a standard. The use of so-called piano wire as a basis for standardizing permanganate and bichromate solutions cannot be too strongly condemned. Electrolytic iron is difficult to prepare and it too, is not as pure as could be wished. The chief difficulty before us is to secure from manufacturers an article of sufficient purity in the large amounts called for. If found, it will be tested by us and issued under our seal. Should success attend our efforts in this case, we may go farther.

Having thus dwelt at some length on that feature of our work that is likely to appeal most strongly to chemists as a whole, I will pass over others more briefly.

Various Bureaus of the Government have called on the Standards Bureau for assistance. These requests range from simple requests for tests of materials to those that involve more or less extended research. Six months was required for a research on pyroxylin plastics with reference to their acceptance or rejection as freight on American passenger vessels. The Treasury Department wants information to enable it to draw specifications for its various record inks and to improve their quality. The government printing office needs similar information in regard to its papers. In fact, the Standards Bureau has for some years done the greater part of the physical and chemical

testing of papers for that great printing establishment, and frequently analyzes the metals and alloys that enter into the composition of type-metals or find direct use in printing. This work requires not only the time of one chemist for the routine work, but of another for research connected with paper.

The following list embodies tests that were made by us in one year: Papers, writing and printing inks, mucilage, lubricating oils, fuel oil, linseed oil, turpentine and white lead, paints, gelatine compound, boiler compounds, soaps, rubber hose and valves, silks, brines, electroplating solutions and scrapings from anode plates, flooring compositions, silicate brick, glasses, gypsum, boiler tubes, steels (other than those in our list of analyzed samples), graphite, tinfoil, solder, monotype metal, antimonial lead, jute bagging, rasped pine sawdust cover for paper rolls, condenser tubes and water guide rails. Many of these called for far more than routine testing.

In consequence of recent legislative action by Congress it is probable that a vast deal of work in connection with the testing of structural materials will devolve upon the bureau. Its proper attention will require large additions to the chemical force and necessitate the erection in the near future of a building specially devoted to chemistry.

As is generally known, the units in terms of which practicaly all electrical measurements are expressed, are the International Units defined in terms of concrete standards, and not the absolute units of the C. G. S. System. The latter have been displaced, for the present at least, on account of the higher accuracy attainable with the former by the aid of carefully drawn specifications.

To secure the highest attainable accuracy, the chemist must be called upon to study the methods of purification or preparation of the materials employed, to develop special methods of analysis, qualitative as well as quantitative, and incidentally to investigate various problems such as arise in connection with every research.

The London International Electrical Conference of 1908 adopted the International ohm and ampere, defined in terms of the mercury column and the voltameter respectively, as the two fundamental units. The Weston Normal Cell, which must however be employed to fix the results of voltameter work, was adopted as a secondary unit.

Owing to the difficulty of reaching agreement in specifications, this question and others were assigned to an International Scientific Committee of fifteen, under the auspices of which a meeting of representatives of the National Laboratories of Germany, England and France was recently held at the Bureau of Standards. The object was to compare the results obtained with the types of voltameters used in the various laboratories and to compare standard cells representing the procedures adopted in those institutions as well as to investigate sources of variations in the results, in order to pave the way for the adoption of uniform specifications guaranteeing the highest accuracy of reproduction.

The results, though incomplete, are to be regarded as most satisfactory, but cannot be discussed here. The services of a chemist were needed during all the work on the voltameter and for many months in advance of the coming of the foreign delegates. To his skill was due in large measure the unraveling of some most troublesome and obscure points in the action of different types of Coulometers and of the solutions employed in them.

The main chemical questions that have a bearing on the results of voltameter measurements are the following:

1. The preparation of pure silver nitrate.
2. Methods of testing the purity of silver nitrate.
3. The influence of impurities in the electrolyte.
4. The contamination of the electrolyte by the septum employed or by the electrolysis effected.

The chemical side of the reproductibility and constancy of the Weston Cell as a standard of electromotive force has been under consideration at the Bureau of Standards for some time, with the result that an accuracy of reproduction of two or three parts in 100,000 is now attainable. (Parenthetically it may be said that a like degree of accuracy is striven for in the reproductibility of conditions and results by the voltameter, that is, of at least two or three parts in 100,000 as a mean of several determinations.) The work with the Weston Cell has embraced the investigation of equilibrium conditions in the cell, the methods of washing, and the hydrolysis of the depolarizer, mercurous sulphate, the preparation and purification of the materials mercury, cadmium, mercurous sulphate and cadmium sulphate, and the effect of added impurities.

It is hoped that the ultimate result of the international comparison of cells and voltameters and the exchange of the various materials will result in the adoption of uniform specifications for these materials. The bureau has made the proposal that when this shall have been effected the various national laboratories shall undertake to furnish such materials ready for use to investigators and others.

The need for a new and authoritative table of densities of alcohol-water solutions has long been apparent. Fundamental for this is an exact determination of the density of absolute alcohol. The data heretofore chiefly relied on are those of Mandeleef and the Squibbs, but these differ, hence the desirability of a new determination, which necessitates the prior preparation of pure alcohol, a most difficult problem. How this has been done is described in a paper by Mr. E. C. McKelvey, which I shall have the pleasure of presenting in abbreviated form at this meeting.

An investigation is in progress, having in view the unification and simplification of methods of gas testing in this country. An important point in connection with

this relates to the permissible limit for hydrogen sulphide in illuminating gas, and the accurate and quick determination of the amount present. In co-operation with the proper physical division a chemist is at work on this problem.

Another has worked in co-operation with the heat division of the bureau in the preparation of the pure materials for calorimetric comparisons, of which I have already made mention.

This latter research is closely related to another, namely, that of determining the heats of combustion of methane and ethane, ethylene and acetylene, carbon monoxide and hydrogen, which are needed as fundamental constants for a study of the calorimetry of illuminating gases. The above named substances must be prepared in a state of great purity and for their combustion large quantities of very pure oxygen are needed. One chemist in co-operation with our very efficient glassblower has devised a generator for oxygen and hydrogen consisting of nine cells. The electrode are of wrought iron and are separated by a glass bell-jar. The electrolyte is caustic soda of 20 per cent strength. The cells are electrolytically in series and the current used about 20 amperes. With this current the yield of oxygen is about 47 liters per hour. The gas is passed through a platinized quartz tube two meters long, then through two towers filled with solid potassium hydroxide, then through a soda-lime tower, and finally through a calcium chloride tower. The gas is then compressed into cylinders at 100 atmospheres pressure by a special mercury piston pump. It is expected that the bureau will, in future, draw its supply of oxygen and hydrogen from this source.

A comprehensive co-operative study of underground electrolysis and corrosion is to be started this year, and for this the services of two chemists will probably be needed.

Finally, a long investigation, still unfinished, is the determination of the atomic weight ratio between bromine and hydrogen. This research forms a logical extension of that already done at the bureau by Drs. W. A. Noyes and H. C. P. Weber on the ratio between chlorine and hydrogen, a work that was crowned some time ago by the award of the Nichols medal.

The force of chemists now employed numbered thirteen on June 30th, which number will be increased from four to six this summer and probably by a number of others. At present the quarters are uncomfortably crowded, but before the summer is over additional room will be provided to accommodate seventeen or eighteen in all.

There is a weekly journal meeting for the chemists, also certain courses of lectures and laboratory work to aid those who desire to take advanced university degrees. This latter work is done out of office hours and is accepted by some universities.

In the foregoing, I have endeavored to outline in the briefsst possible manner the character of the chemical work done at the bureau. You will see that it is most varied and that administration and correspondence must necessarily make such large demands on my own time as to leave little for direct experimentation. The most that I can hope to do must be at odd moments, but it is my hope and wish to be able to exercise direct supervision over the more exact analytical work, so far as this falls in line with my personal acquaintance.

The bureau will before long, I hope, do its full share in the way of publication to forward the science of chemistry, both practically and theoretically. But the bureau is yet young and so are most of its chemists. Hence active publication from the start is not to be expected, for unusual care must be taken that work of doubtful value shall not emanate from an institution which should be what its name implies, a Bureau of Standards. It is too much to hope that this will never happen, but my aim will be to keep it at a minimum.

THE USE OF SODIUM BENZOATE AS A PRESERVATIVE IN FOOD.*

By H. E. BARNARD.

Food and Drug Commissioner of Indiana.

Sodium benzoate belongs to the class of preservative agents usually known as chemical in distinction from the so-called condimental preservatives, sugar, salt, vinegar and spices. This classification is a good one, for although sugar and salt and vinegar are chemicals no less than sodium benzoate their chief use is as condiments and their preservative property, while of great value, is not the primary reason for their addition to food.

At the present time in normal years the production of foodstuffs is sufficient to meet the demand and provide a surplus. How best to preserve the crop of an abundant harvest against the time of under-production is an economic problem of tremendous importance. In addition it involves the utilization of products which would otherwise go to waste and the distribution of the crops of one season throughout the year, and makes it possible for all parts of the world to enjoy foods grown under different conditions of soil and climate.

Certain foodstuffs, especially the cereals, do not easily decay or deteriorate and need only suitable storage to hold them in proper condition for use. Other foodstuffs, such as the meat supply, are very perishable and must be transported either as the live animal or when protected against decomposition. Still other products, such as fruits and vegetables, are not transported or stored in their raw state except in a limited way for local consumption, but are usually prepared for use before being placed in the market.

It is said that one of the first steps from savagery towards civilization was the acquirement of the art of food preservation. The use of heat, smoke and salt as food preservatives was a tremendous advance and

*Address given at summer meeting of Amer. Chem. Soc.

still later the discovery of the properties of vinegar, spices and sugar increased the ability of the producer to conserve surplus food. The greatest single step forward in the science of food preservation was the discovery and application of the process of sterilization, and this method is now applied to an enormous extent in the preperation of goods put up in hermetically sealed packages. In recent years, and especially since the dawn of modern chemistry, many attempts have been made to develop a food preservative which would be efficient and cheap. Following this desirable line of investigation the use of one chemical after another of known antiseptic properties has been suggested. Within the last 30 years we have seen advocated, used for a time extensively and finally abandoned, either because the manufacturers themselves found objections to it or because of legislation enacted in the interest of the consumer's health, borax and boric acid, salicylic acid and its salts, sulphurous acid and the sulphites and formaldehyde. Lesser known preservatives which have been occasionally used are the flourin compounds, abrastol, formic acid and the peroxids. At the present time all of these preservatives are under the ban of the law and are not employed by manufacturers.

To be suitable for use in foodstuffs designed for general consumption, a preservative must possess definite, positive and negative characteristics. First, it must not under any reasonable conditions injure the health of the consumer. Second, its use must not make possible the employment of careless and imperfect methods in manufacture. Third, it must not allow the utilization of unfit raw material. Fourth, it must be non-irritant. Fifth, it must not retard the action of the digestive ferments. Sixth, it must be efficient in its action. Seventh, it must have no tendency to decompose in the body into substances the dose of which is smaller than its own.

It is axiomatic that no manufacturer has a moral right to put into food any substance which may possess undesirable characteristics and it therefore becomes imperative upon the user to prove that the drug in question meets all of the conditions above cited. It is not the duty of the official or of the public to determine whether or not substances added to food as preservatives are suitable for use. On the contrary it is the duty of the manufacturer to show that they are suitable substances to be used in food. Unfortunately in the past, food manufacturers have not followed this logical method of procedure but have seized upon any chemicals which seemed to them to possess meritorious qualities and have left it to disinterested investigators or to officials to develop the fact that they are injurious and finally to compel their dis-use.

The one substance of a chemical nature other than the so-called standard preservatives, salt, sugar, vinegar and spices, which is still occasionaly employed in a certain class of food, is sodium benzoate, the sodium salt of benozic acid. Over the use of this preservative has been waged a war that has shaken the very foundations of food legislation and which for a time threatened to involve manufacturers and officials in an endless conflict.

Its use was first prohibited by those charged with the enforcement of the Federal Food Law, and later permitted. Many of the States have followed the Federal regulations in the interpretations of their food laws, other States have specifically denied manufacturers the right to use sodium benzoate in foodstuffs, and still other States the laws of which allow only the use of the condimental preservatives have refused to accept the Federal ruling and contest the legality of the sale of all foodstuffs containing these presrvatives. It is desirable that out of this conflict of opinions the exact facts as to the permissibility of sodium benzoate in foodstuffs be determined, for it is either a satisfactory preservative or it should not be used. What are the facts? Does it meet the conditions imposed?

Is sodium benzoate injurious to health? As in every question, so here, a mass of evidence can be presented on both sides. It is declared injurious by able scientists; it is declared non-injurious by other scientists. Human subjects who have been fed food containing sodium benzoate have been injuriously affected. Other subjects who have taken similar food do not appear to have suffered appreciably. In animal experiments, certain animals have been killed with sodium benzoate. Other experiments have shown that non-injurious results followed its ingestion. Out of such a mass of conflicting data it is hard to determine the exact truth. Negative evidence, however, must be considered to have little value as compared with positive evidence, and the fact that ten subjects failed to contract smallpox when exposed to the disease, but that the eleventh did contract the disease, does not prove that smallpox is not infectious. On the contrary the fact that one person out of the eleven exposed contracted the disease proves beyond question its infectious character. With equal truth then, it must be assumed that if one person is injured by eating food containing sodium benzoate although ten are not injured, the preservative must be considered to be injurious to health. Furthermore the fact that healthy and vigorous men have been able to ingest benzoated foods without appreciable injury offers no evidence to show that similar results would follow the ingestion of similar foods by subnormal persons, such as children or the aged, invalids or convalescents.

Does the use of sodium benzoate make it possible for the manufacturer to use careless and imperfect methods?

Any preservative must in a measure pave the way for careless handling. This is true of the condimental as well as chemical preservatives, the difference between the two classes being that the first cannot be used to excess without destroying the palatability of

the food. Sodium benzoate possesses in its natural state no marked taste or odor and for that reason may be employed in any quantity that the manufacturer may wish to use without the consumer becoming aware of the presence of the drug. It is a fact that at the present time, since the dawn of the new era in sanitary production, the producer whose equipment is complete and whose technic is good does not find it necessary to use any preservative other than the standard and accepted method of sterilization re-enforced as may be necessary to suit the public taste by the addition of salt and sugar, and in the case of some goods vinegar and spices, while on the contrary the man who is poorly equiped and whose methods are not up to date still feels compelled to use preservatives to hold his goods in marketable condition.

The third condition that preservatives must meet if they are to be allowed, is that they do not make possible the utilization of unfit raw material. During the benzoate controversy much time and energy has been spent in attempting to show that the use of sodium benzoate does not allow the manufacturer to work up poor material and experiments have been made over and over again by taking decomposed tomato pulp and preserving it with sodium benzoate and from the results of such an experiment the strainer inference drawn that it is impossible to use the preservative as suggested. A microscopical study of catsups shows that the goods put up with the preservative show far more evidence of the use of decomposed material and the presence of yeasts, mold spores and bacteria, and this in spite of the fact that the quantity of preservative present was more than twice that of the proverbial one-tenth of one per cent. On the contrary, the goods put up without preservatives were uniformly made from sound material.

While sodium benzoate has not been largely used as a milk preservative, in some way it is admirably adapted for such use. It will prevent the growth of lactic acid bacteria, but is not a sufficiently energetic preservative to effect materially the growth of other organisms which, while not normally present, are found in most market milk and which by their growth produce the ptomaines and food poisons about which so little is known except their extreme toxicity. When ingested in unpreserved milk the fact that milk is old and therefore unfit for food is always betrayed to the consumer by the acid taste. If preservative is used it retards development of acidity and so destroys the only positive test by which the consumer is able to guard against drinking milk unfit for food.

The fourth requirement of a preservative is that it must be non-irritant. Sodium benzoate in the form of the salt is a relatively bland substance. Unfortunately for its use as a preservative it is usually employed in acid foods and is present not in the form of the salt but as benzoic acid, and benzoic acid is decidedly irritant. Certain experiments recorded by Dr. Lucas in a recent issue of the Journal of the American Medical Association[1] shows conclusively this irritant action.

This action of benzoic acid is also shown by Wiley in his report of a study of the effect of benzoic acid and benzoate on digestion and health[2]. Herter also records similar results following ingestion of sodium benzoate[3]. The U. S. Dispensatory refers to it as irritant to the alimentary mucous membrane[4].

Fifth, does sodium benzoate retard the action of the digestive ferments? Fortunately it is possible to obtain positive data on this point if it be assumed that digestion in vitro is comparable to natural digestion, for most digestive ferments may be readily obtained and used under varying conditions in artificial digestion experiments. The literature records many such experiments and students of metabolism and chemical physiology accept the results obtained as of positive value. The action of sodium benzoate on digestive ferments has recently been studied by a number of investigators, notably Robison[5] and Shepard[6].

We have recently conducted a series of experiments to show the effect of sodium benzoate in checking the artificial gastric digestion of egg albumin. 1 gm. cubes of hard boiled egg albumin were placed in Erleynmeyer flasks and 100 c.c. of artificial gastric juice containing .10 gms. of pepsin and .20 per cent of hydrochloric acid. To different flasks was then added varying quantities of sodium benzoate, namely, .05 of 1 per cent, .1 of 1 per cent, .15 of 1 per cent, .2 of 1 per cent, .1 of 1 per cent and .5 of 1 per cent, and a blank was also run in which digestion was allowed to proceed unhampered. The flasks were incubated at blood heat until the albumin was almost but not quite digested. This was usually accomplished in about 22 hours. The undigested albumin was then removed and preserved by placing in test tubes and covering with 180 proof alcohol. The albumin in the solution containing .5 per cent of sodium benzoate was practically digested. In the .3 per cent solution there was slight digestion, in the .2 per cent solution there was 50 per cent digestion; 75 per cent in the .1 per cent solution and 90 per cent in the .05 per cent solution. This experiment was varied by using different amounts of hydrochloric acid in different tests, the amounts used varying between .15 and .3 per cent, thus producing an acidity both less and greater than that in normal gastric juice. The effect of the preservative upon digestion in these solutions was not different from that described.

In order to determine the effect of sodium benzoate and benzoic acid upon the development of yeast and the process of fermentation a series of experiments were carried on with sweet cider to which had been

[1]Journal American Medical Association. Vol 54. Some Effects of Sodium Benzoate. Lucas, pp. 759-766.
[2]Wiley-Benzoic Acid and Benzoate. Bulletin 84.
[3]Herter. "The Action of Sodium Benzoate on the Human Body." Report 88 U. S. Dept. of Agriculture.
[4]U. S. Dispensatory. Page 24.
[5]Bulletin 167, Michigan Drug and Food Department.
[6]Unpublished report to committee of 11.

added quantities of sodium benzoate varying from .1 to .2 of 1 per cent. The cider containing preservative was placed in inverted burettes which stood in wide-mouthed Nessler tubes plugged with cotton. The cider in the burettes was inoculated with a concentrated solution of baker's yeast and the rapidity of gas formation determined by noting the cubic centimeters of gas which collected in the burette. A control was run as in the other experiments. At the end of 24 hours fermentation had proceeded in the control tubes until they were empty. All the other tubes showed no fermentation 12 days after inoculation. A second experiment was then run using .02 per cent, .05 per cent, and .08 per cent sodium benzoate and benzoic acid. This experiment was designed also to show the relative preservative values of sodium benzoate and benzoic acid. At the end of 18 hours the control tubes were empty. Fermentation began in the case of .02 per cent sodium benzoate at the end of 36 hours and proceeded with increasing vigor until the tubes were empty at the end of 92 hours. The cider preserved with benzoic acid did not begin to ferment until after 72 hours had elapsed and the tubes were empty at the end of 156 hours. There was no production of gas in the cider containing .05 and .08 per cent of sodium benzoate and benzoic acid. A similar experiment was conducted using beer wort as media and inoculating with brewer's yeast. In this case the concentrations of preservative were .05 per cent, .1 per cent, .15 per cent and .2 per cent benzoic acid and sodium benzoate. The control tube was empty 24 hours after inoculation. The tube containing .05 per cent sodium benzoate was empty at the end of 27 hours and the tube containing .1 per cent sodium benzoate was empty at the end of 29 hours. The tube containing .05 per cent benzoic acid, .15 per cent sodium benzoate and .2 per cent sodium benzoate was partially but not entirely empty at the close of the experiment. Ten days after inoculation tubes containing .1, .15 and .2 per cent benzoic acid showed no signs of fermentation during the experiment. In addition to recording the fermentation in terms of gas production the increase over the initial acidity was determined from day to day in both the cider and beer wort experiment. The results obtained are comparable with those just given and show first that sodium benzoate and benzoic acid even in concentrations of .05 of 1 per cent materially affect the fermentation and consequent development of acidity. They show secondly that benozate of soda is a far less effective preservative agent than benzoic acid, the relative activities being about that of 1 to 2. We shall later publish the results obtained in these experiments with charts which show graphically both gas production and development of acidity. Our experiments as well as those of others show conclusively that sodium benzoate retards the action of the digestive ferments and that benzoic acid is much more active even than sodium benzoate.†

† Herter, Journal Biological Chemistry, Vol. VII, p. 59.

The sixth desideratum of a preservative is that in the quantities used it accomplishes its purpose, namely, that of preventing the growth of moulds and ferments and consequent spoilage. Sodium benzoate does not fulfill this condition and in the concentration popularly supposed to be employed in foodstuffs, namely, .1 of 1 per cent, is practically worthless.* That manufacturers have realized this is shown by the fact that their goods although labeled one-tenth and one-twelfth of 1 per cent have almost invariably contained from .2 to .3 of 1 per cent. Recent analyses of 117 samples of catsup in our laboratory have shown the average content of sodium benzoate to be .194 per cent. But two samples contained no more than the amount stated on the label.

The seventh requirement of a preservative is that it must have no tendency to decompose in the body into a substance the dose of which is smaller than its own. In other words, it must not change its form in the process of metabolism. As already shown sodium benzoate, the form used in the preservation of food, is decomposed in all acid products into benzoic acid and some other more stable sodium salt. If it is not decomposed in the food itself it inevitably is broken up by the hydrochloric acid of the gastric juice with the formation of benzoic acid and sodium chloride. The person taking this preservative does not get the effect of the salt but of the acid.

The facts as I have stated them may perhaps be considered more an argument against the use of sodium benzoate in foodstuffs than an impersonal discussion of the merits and demerits of the preservative. They have been developed in a series of hearings before the Federal court in a case brought to test the constitutionality of the Indiana Food Law, with special reference to that section of the law which prohibits the use of preservatives. It is needless to say that the friends of sodium benzoate advanced every argument, scientific and otherwise, which could be mustered in the support of their use of the preservative. Out of the mass of data in the hands of the court I have endeavored to extract such evidence as bears upon the point in question, and the fact that sodium benzoate does not measure up to the standard set for a food preservative in any one of the seven cardinal attributes, leads me to the conclusion that sodium benzoate should not be used as a food preservative. The fact that the food manufacturing industry has established beyond question that it is not necessary either for the preservation of the raw material or the finished product, that the jobber and distributer experience no difficulty in handling goods which are put up without it and that the consumer, more conservative in the matter of the selection of his foodstuffs than in former years, is discriminating in favor of unpreserved foods, relegates sodium benzoate to the shelves of the laboratory by the side of borax, salicylic acid and formaldehyde.

THE PLANT.

THE TREATMENT OF GASES.

By OSKAR NAGEL, Ph.D.

The treatment of gases is a procedure of the greatest importance in the manufacture of a great many inorganic chemicals. In the manufacture of muriatic acid

Fig. 1.

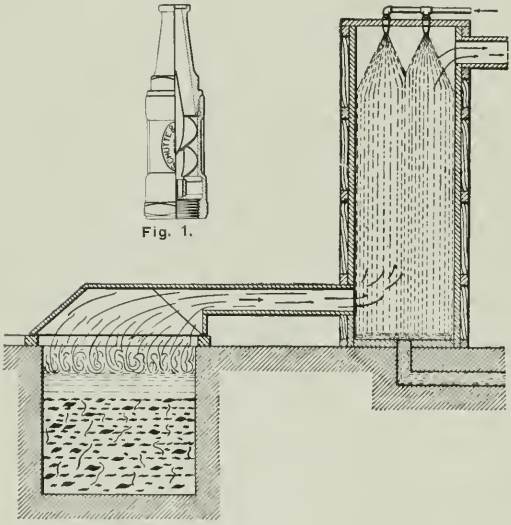


Fig. 2.

hydrochloric acid gas is absorbed by water; in the sulphuric industry gases are washed, cooled and absorbed; in many industries gases are dried, in others they are put to reaction with liquid chemicals or solutions of certain substances.

Wherever a gas is to be washed, absorbed, cooled or dried by means of a liquid an intimate contact between the two media is naturally essential if the operation is to be carried out with fair economy. The more intimate the contact the less time is required for the process; furthermore with increasing intimacy the space required to accomplish the reaction will decrease, which means a smaller apparatus, i. e., lower first cost.

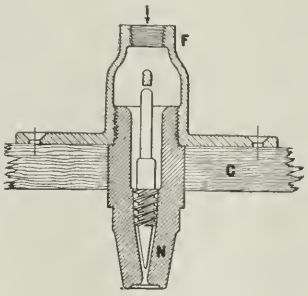


Fig. 3.

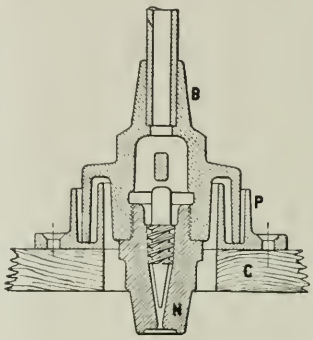


Fig. 4.

Towerlike structures are generally used for these processes, the gas, as a rule, entering at the bottom and rising to the top, while the liquid is admitted at

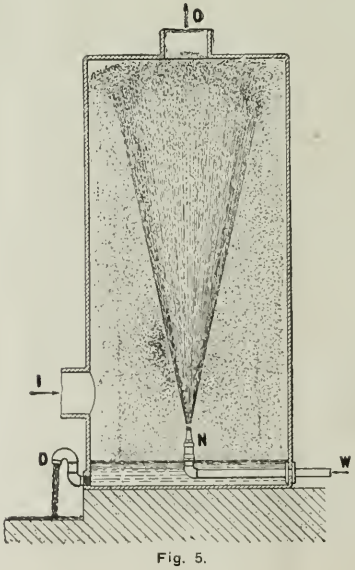


Fig. 5.

the top and leaves at the bottom. In order to obtain an intimate mixture both components have to be brought together in a finely divided state. Since the gaseous component is in itself always in an atomized state on account of being gaseous, it only remains to atomize the liquid in a suitable and economical manner.

The most convenient means for atomizing liquids of any kind is the well known Koerting spray nozzle, which is illustrated in Fig. 1. If a liquid enters this nozzle at high pressure a centrifugal motion is imparted to the liquid with the effect, that, on leaving the orifice of the nozzle, it flashes apart into the finest atoms. This nozzle therefore is an excellent appliance for the treatment of gases by means of liquids.

A typical installation for treating gases by means of spray nozzles such as used for the absorption of hydrofluoric acid in superphosphate works is shown in Fig. 2. In the application referred to a hood is placed over the pit and is connected to a wooden tower, at the top of which hard rubber spray nozzles are fixed. The

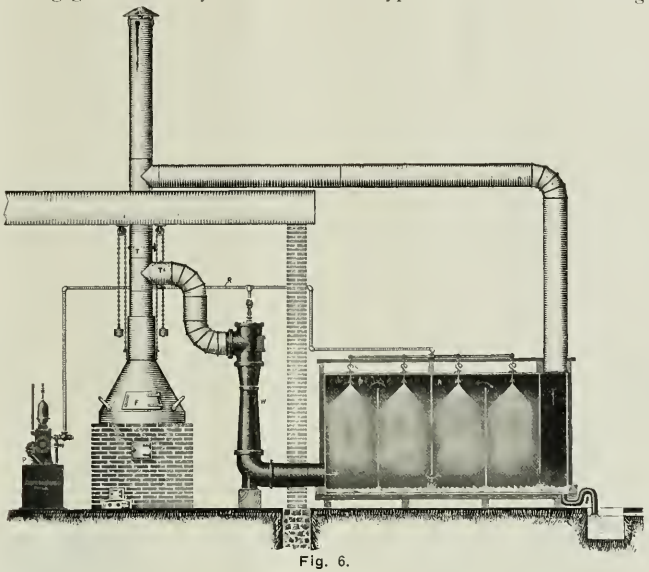


Fig. 6.

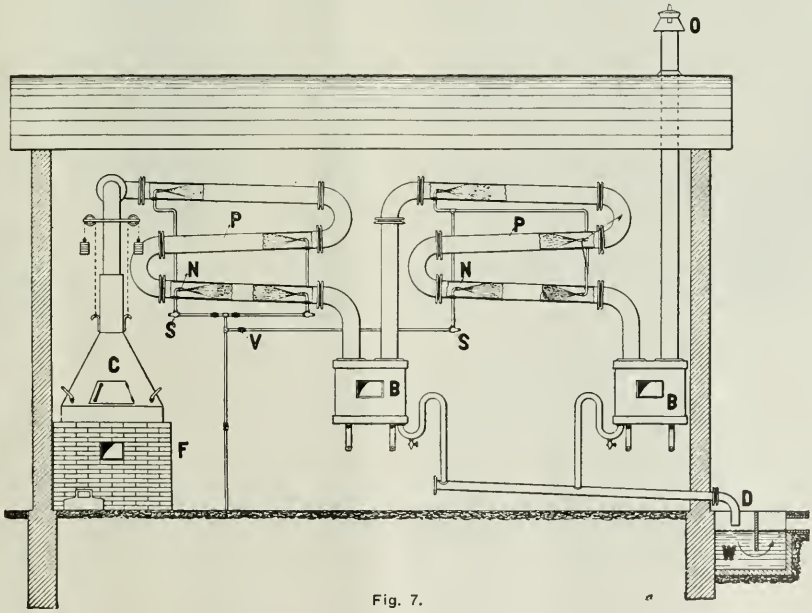


Fig. 7.

tower has conveniently the dimensions 6′x6′x30′. The purified gases pass through the outlet to a chimney or fan. The hard rubber nozzles used for this purpose are illustrated in Figs. 3 and 4. Fig. 3 is arranged for rigidly connecting the nozzle to the chamber, while Fig. 4 is equipped with water seal, which has the advantage that the nozzle can be easily swung out for inspection.

In some instances it is preferable to have both the gas and the liquid travel upwards, as shown in Fig. 5. N is the nozzle, I the gas entrance, W the water or chemical solution and D the overflow for the liquid.

In cases where the reaction desired goes on but slowly, the contact between gas and liquid has to be prolonged in order to insure satisfactory absorption, washing, drying, etc. Installations of this kind are shown in Figs. 6, 7 and 8. In Fig. 6 the fumes are sucked off by means of a water jet exhauster and

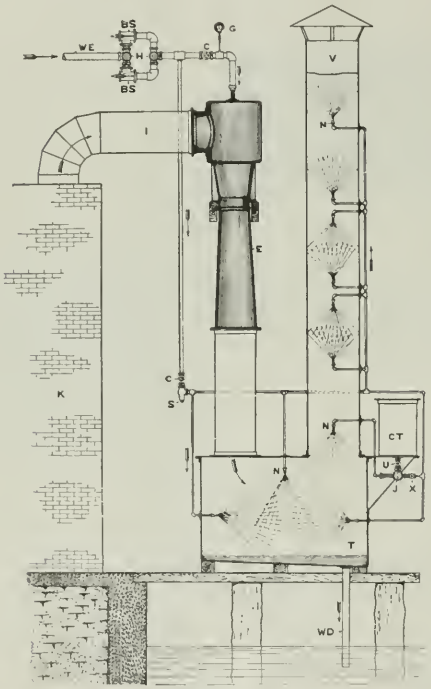


Fig. 8.

pressed successively through the partitions of the absorption chamber. Fig. 7 illustrates the absorption of vapors of paint and varnish factories. Excellent results are accomplished in this instance by centrifugal spray nozzles, as the water consumption is very low and as, furthermore, the necessary draft is created simultaneously without any extra expense. Hoods C, connected to a piping system P, are placed on top of the furnaces F. Spray nozzles N are provided in the piping, a draft being created in the direction of the water sprayed. The vapors are condensed by being sucked into the water sprayed. The cooling water and the condensed oil flows into oil separators B. The plant shown in Fig. 8 will be readily understood from the cut.

In processes where a large volume of gas is to be treated with a small quantity of liquid and where an admixture of steam to the gas does not harm, the steam jet agitators are frequently used, Fig. 9. These agitators are easily installed, occupy small space, work automatically and are of low first cost. Their action is based upon the fact, that a steam jet passing from a smaller into a wider nozzle moves the surrounding air at a velocity sufficient to overcome a pressure of 8′ of water. The steam-gas mixture escaping with great force from the holes of the pipe provided at the bottom of the tank (Fig. 10), causes a violent agitation of the liquid and brings about an intimate mixture of the liquid and gas.

The location of the agitator is preferably so arranged that its head stands above the highest level of the liquid. The distributing gas pipes have two rows of holes, equally distributed and pointing downward.

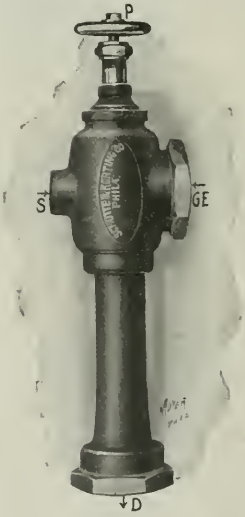


Fig. 9.

The number of these holes are fixed by the rule that the combined area should equal twice the area of the air pipe of the agitator.

According to U. S. Consul John F. Jewell of Melbourne, tungsten occurs in several Australian States, the chief supply being obtained from Queensland and Western Australia. The exports of wolfram from Australia in 1908, the latest statistics available, amounted to 14,080 cwt., most of which went to the United Kingdom and Germany, the latter taking about one-third of the production.

ELECTRICAL POWER IN THE CHEMICAL WORKS.

By WARREN H. MILLER.*

The advisability of introducing electric power into the chemical works is still more open to question than that of electric light. It boils right down to fire risk and insurance, just as it does the latter. The incentive to use it, however, is strong, so strong that it pays well to devise a safe and durable system of distribution and cut off all the steam waste of the numerous small outlying steam engines needful to drive fans, etc., about the plant and substitute electric motors, thereby cutting the power bill to less than one-half.

In the large chamber-process sulphuric acid plant

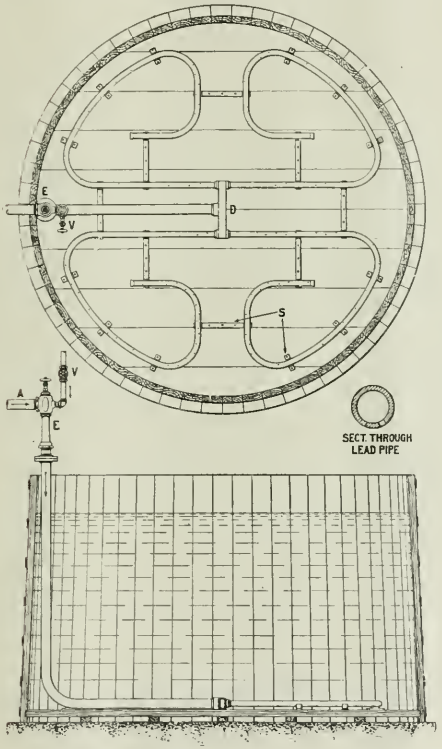


Fig. 10.

mentioned in a previous article on electric light†, the question of power was attacked along these lines because the steam problem had become acute, owing to numerous increases in the still outfit. As will be recalled, the voltage chosen for the lights was 220 volts because it would allow the use of power without introducing transformers or separate power dynamos, and this voltage proved a wise choice, as there has never been any trouble from the 220 volt filament. Having fixed the voltage, the next question would be what kind of power to use,—alternating or direct current. The deciding factor in such selection would not be the possibilities for arcs, nor of variable speed, but simply the motors themselves. In a chemical works of this character, the air is very heavily impregnated with acid vapors,—so heavily that tackle cannot be left out over night without vitiating the ropes, besides the iron oxide ore dust which forms the residue in the roasting furnaces after reducing the iron pyrites is an excellent conductor of electricity and is everywhere about the plant, settling on beams, floors and all running apparatus. There is no avoiding or confining this dust, as it is carried by the wind to all parts of the works, when dumped into cars for transportation and sale. Therefore the motor must either be totally enclosed "marine" type or else of a kind that will not be at all affected by being covered with dust and condensed sulphuric acid vapors. The direct current totally-enclosed motor seems at first thought to be the best type for this installation, but in actual practice the personal equation enters, and it does not keep up to the ideal that its makers conceive. To begin with, very few makes can be relied on to carry a steady load, week in and week out, twenty-four hours a day, without getting hot; whereupon there is nothing to do but to open up at least one of the covers to let out the heat—and let in the ore dust. The covers must screw down onto rubber gaskets so as to make the motor absolutely water tight, as the dust will find its way in through the remotest crack. Even if it is well enough built to run cool under such air-tight condition, the covers will have to be unscrewed at least twice a week by the works electrician to examine brushes and commutator; which individual soon makes the marvelous discovery that it is easier to get the covers off to examine and clean the brushes if the screws are only screwed down by hand, with possibly a final "set" with a horny thumb-nail. From that time on the motor slowly accumulates dust, all of which collects on the commutator in front of the brushes, forcing them to spark,—which is rather discouraging to the commutator bars. All of these possibilities are circumvented by adopting the 3-phase alternating-current induction power. This is absolutely fool-proof, as it has no brushes, doesn't have to be hermetically sealed, and runs equally well whether buried in ore-dust or kept clean. All there is to the running part is two ring-oiled bearings, giving no more trouble than so much mill-shafting. The only thing you have to protect it against is promiscuous oiling with a squirt-can. The oil-wells are already full, and hold oil enough to run the motor several months without replenishing, but this circumstance is generally lost on the still foreman, who religiously squirts oil into the bearings. Whereat a corresponding amount of oil comes out at the overflow and drips down to the floor, much of it being drawn into the rotor by the strong suction of the motor. No electrical insulation will

* Bay Head, N. J.
† The Chemical Engineer, September, 1910.

stand a continuous bath of oil drippings. The only other protection required by the induction motor is to tar thoroughly both rotor and stator coils before putting the motors into service. Both of them are made of laminated soft steel plates, and it is important to prevent the acid fumes from sulphating in between the laminations. This was effectually done by tarring them, and during the last two years no trouble has been experienced from this cause.

Turning to the starting arrangements of both direct and alternating current motors, we find in the direct current a box of iron resistance-coils which obviously cannot be sealed up, and a slate face mounting the magnetic release, the swinging arm and the button contacts. All of this will fill with dust unless enclosed in a switch-box, and is a more or less delicate matter for ignorant works foremen to handle. With the alternating current motor the starter is a cast-iron totally enclosed oil-immersed transformer, with a cast-iron handle which only has to be put on starting position and left there until the motor comes up to speed, which will be in about four seconds. It is then thrown to running position, where it locks. A fool-proof device, which can neither be broken, nor put out of order, nor left on starting position, as the handle will fly back to "off" if you do.

A final question that might be raised is the desirability of having a variable-speed motor for the fans. This can be done with either direct or alternating current motors, but is strongly to be advised against, as either will introduce resistance grids and similar complications. With the small steam engines the fan speeds are altered by throttling the engine and adjusting the governor, and also by adjusting the dampers in the delivery pipes into the various towers. As a fan uses only as much power as the volume of gas passing through it, and is in no way incommoded by closing the dampers to any degree required, the best plan in using motors is to have them constant-speed and adjust the amount of vapor passing into the towers by dampers or gates. There is no waste of power or loss of efficiency in this, as the pressure is entirely a function of the speed of the fan and does not rise a particle even if the dampers are all closed tight shut. In this case the light-load on the motor would drop to merely the friction of turning the fan, the gas going around with the blades of the fan instead of leaving by the outlet.

As the human element has quite as much to be reckoned with as the mechanical element in choosing any system of drive, the 3-phase alternating current motor was adopted as being the most simple and adaptable drive for the fans, shops and elevators about the plant. The only case where it failed was in the recovery inlet fan-room. Owing to the nature of the recovery apparatus, which was simply a long lead passage, about 10 ft. wide by 20 ft. high by 300 ft. long, open at the bottom to the air, the air of this room was simply a fog of weak sulphuric acid vapor. Two motors were put in here before anyone appreciated the necessity of tarring the rotor and stator core, and in a month or so both were badly grounded, and burnt out one leg of the stator.

All the other motors, seven in all, running fans here and there about the plant, worked steadily day and night without the slightest trouble, and have never required any repairs. They were 3-phase, 220-volt, 60-cycle Westinghouse simple induction motors, running at 1200 R.P.M. and belted to the same countershaft as the engines, thus allowing the latter to remain useful as stand-bys. The full load was 5 Kw., and light friction load less than ½ Kw. as near as could be measured.

The elevators, at first thought, seemed to be apt to cause trouble at the power house. As is well known, the starting current of an alternating current motor is very large compared to its running current if some heavy load has to be gotten in motion, such as an elevator platform carrying a 2-ton car of ore. There were many headshakings as to the effect of this in pulling down the line voltage all over the plant, and possibly upsetting the entire system unless the generators were made extra large, and all sorts of elaborate variable-speed starting schemes were proposed to ameliorate this evil. But the writer did not propose to complicate his plant with any such devices, nor did he propose to make the generators a particle larger than normal for the given motor load. To begin with, any form of elevator-starter, other than the usual pull-rope, would be beyond the brain-power of a Hungarian ore-pusher, so we eliminated the electric starter at once.

Before installing the electric motors the elevators were driven by steam-engines belted to shop elevators, belt-driven as is usual with this type. Most of the time the engines were on light friction-load, which of course wasted a good deal of steam, but it had the undeniable advantage that the elevator would always run when wanted by the simple expedient of pulling on its rope. It further made no difference how hard you pulled on it, nor how violently you shut it off.—the thing was indestructible as far as human strength was concerned. This state of affairs was too good to lose, so we decided to simply substitute a motor running at constant speed for the engine and retain the invaluable elevator-rope. To avoid the rush of current on starting such a heavy piece of machinery, the writer decided to use a scheme which has often proved successful in running air-compressors, bulldozers, bar-shears and such tools giving an intermittent load. This consisted simply in putting on a heavy 300-lb. flywheel on the stub end of the motor shaft. This wheel was 27 in. diameter by 3 in. face with 4 in. depth of rim and 1 in. solid web. Running at 1200 R.P.M. it stored a tremendous amount of kinetic energy, enough as turned out later to run the whole elevator from top to bottom without any current on the motor at all. The average hoist was 2 tons, 11 ft. 18

ft., motor 7.5 H. P., Westinghouse simple induction, full load 5 Kw., light load ½ Kw. as near as could be measured, probably about ¼ Kw. The drop in line voltage was 8 volts out of 220 when the elevator was put on,—not enough to appreciably affect the lamps throughout the works. The motor hardly dropped off ten revolutions during the hoist, though without current it would come nearly to a standstill before the 18 ft. lift was accomplished with the energy of the fly-wheel only. It proved a very simple and practicable solution of the problem, and the current consumed in starting the elevator was no greater than with any of the fans. The flywheels were specifically stated to be put on the rotor shaft at the Westinghouse shops and balanced in the lathe, but it slipped through their shop organization without being attended to, so the writer had to balance them all on the job himself, as none of the elevator motors would get up even as much speed as 300 R.P.M. without chattering and shaking the foundations beyond all belief. This balancing was easily done by devising a small iron clip which could be fastened on the rim at any desired point. A few trials sufficed to find the point where the chattering was at a minimum, and, by adding weight at this point, the wheel was balanced so as to run like a top. Having found the point and the weight, the balance was made permanent by drilling an inch hole in the web at that point and bolting on enough washers to correspond to the required weight. They were all balanced true this way and gave no further trouble.

The line connections of all these motors was by porcelain-base knife switches and cartridge fuses, enclosed in a yellow-pine switch-box, as cast iron would simply make a nest of sulphate. If one uses slate bases the same fate is likely to overtake the switches and fuses, but porcelain seems to stand the acid fairly well. The starting leads are attached above the fuse and the running leads below them, the switch cutting out both. After connecting up, the switch was closed and both it and the fuses were tarred all over wherever any metal was exposed to the acid fumes. One must see to it that the electricians do not succeed in getting any of the leads crossed, for all that is necessary to reverse an induction motor is to cross any two of its leads, wherefore if this is inadvertently done, the motor will start up and come to speed in one direction and instantly stop and reverse when thrown on to running position,—which is apt to be disconcerting, at first.

The electric wiring was run in three-wire hard yellow-pine moulding, tarred inside and out, with the wires buried in tar in the grooves, much as described in a previous paper on electric light wiring.* This was only done inside buildings, as it is better to run outside with all the wires in plain sight wherever possible. The top three pins of the 4 in. by 4 in. pine poles bolted to the parapet walls of the buildings were used for power, because it put the three wires in an equilateral triangle at no additional expense. This is desirable because there is then an equal mutual induction between the three wires, but its total effect one way or the other is so slight that there is no objection at all to running all three wires side by side if wiring conditions are more convenient that way.

The main distribution wires were triple-braid weatherproof, varying from 2-0 at the power house to No. 6 at the motors, the mains being calculated for a drop of 5 per cent and using the "star" system of distribution. Rubber-covered will of course be impracticable around an acid plant, as the rubber soon vulcanizes and perishes, but the gum insulation of the weatherproof type resists acid very well if not actually soaked in it. All these wires were tarred immediately upon putting up to protect the triple braiding. A paint brush on a 20-ft. wooden handle sufficed to reach all the spans. To get the wire up smooth and without kinks, each section of three or four poles (spacing 30 ft.) was stretched at the bases of the poles with block tackle, and then lifted up to the insulators, tied in loosely, stretched taut and tied in firmly with No. 6 tie-wire. Always tie the wire on the side of the pin which will screw up the insulator when the wire is slacked back. Otherwise the wire will invariably unscrew the insulator ½-in. and the span will then be baggy and sorrowful to behold. Stranded wire should always be used in general practice in all sizes down to No. 4, but for the sake of greater immunity against acid fumes all this wire was bought solid, hence the stretching before putting up.

All line splices were made with ¾-in. rubber tape and this was tarred and protected with a covering of ¾-in. plain black friction tape. Junctions were made by cast-iron Westinghouse cartridge fuse-boxes, mounted on a suitable board fixture secured by iron between the cross-arms, or on the parapet walls. Always order these with bras thumb-screws as they are usually sent with iron screws and these promptly rust up their threads so that no power on earth can unscrew the wing-nut to open the box.

The power equipment consists of two 50 K. W. Westinghouse alternators, 3-phase, 60 cycle, 220 volt, direct connected to two 12 in. by 12 in. Harrisburg simple non-condensing steam engines. The exciters were 3 Kw. Type S slow speed, 110 volt D. C. dynamos, direct-coupled to the stub ends of the engine shafts, and either one could excite both alternators, besides running the D. C. motor driving the economizer scrapers. As the exciter is the most important small link in the power chain, it will not do to have only one, separately driven, and two of them coupled to the main engines are cheaper and more economical of steam than two driven off a small separate engine.

The switchboard was built by the Walker Electric Co. in 2-in. green Vermont slate which resists acid fumes very well though it is full of shocks on wet days or whenever the stills are turned from the recovery tower into the air. It is a very simple and in-

expensive board for the control of two alternators, two exciters, and a light and power circuit, the whole being mounted on three panels.

The total cost of the electric light and power equipment as described in this paper, the preceeding one on the electric light, and the following one on the power house was $12,200, exclusive of a 1,000 H. P. boiler installation, used, not only for power, but for the much larger work of driving the works pumps, steam air-compressors; and five still-houses.

Consul Albert Halstead reports that for the year ended June 30 the report of the Birmingham assay office shows an interesting growth in silverware tested. In 1899, 1,098,250 ounces were assayed and marked, growing in 1901 to 3,272,950 and in 1910 to 3,992,647 ounces, the greatest on record. The assay of gold ware, on the contrary, shows a decided decrease, 407,608 ounces in 1901, the highest in twenty years, falling to 200,077 ounces in 1910, a decrease since 1900 of 42,414 ounces.

The world's annual production of phosphate rock is about 5,000,000 tons, the United States being the largest producer, with an annual output of more than 2,000,000 tons. Tunis, which ranks second, produced phosphate of a rather low grade to the amount of $6,117,000 in 1908. In 1909 the great Gafsa Company, which owns its own railroad, mined 907,000 metric tons (metric ton = 2,204.6 pounds). It pays a large dividend on its capital of $7,750,000, as is shown by the fact that the stock of this Tunisian company is selling in Paris at a premium of more than 600 per cent. The Pacific Phosphate Company of London, which owns deposits of 50,000,000 tons of high-grade phosphate on Ocean and Pleasant Islands, is mining some 250,000 long tons a year at a profit of more than 50 per cent on its capital stock of $1,210,000. A German company has recently begun to mine phosphate to a considerable extent on the island of Angaur, which lies in the western part of the Carolines at no great distance from the Philippines.

According to a report on the cement industry recently issued by the U. S. Geological Survey more cement was made and used in the United States in 1909 than in any preceding year and the price per barrel was lower than ever before. The production in 1908 was 52,010,025 barrels, valued at $44,477,653; the production in 1909 was 64,196,386 barrels, valued at $51,232,070. The increase was mainly in the output of Portland cement—62,508,461 barrels, valued at $50,510,385, as against 51,072,612 barrels in 1908, valued at $43,547,679. The output of natural and puzzolan cement formed only a small percentage of the total cement production.

The average price of Portland cement per barrel in 1909 was less than 81 cts., the average price per barrel in 1908 was 85 cts. Portland cement cost $3 per barrel in 1880, but by reason of improvements in methods of manufacture it can now be profitably sold for 80 cts. per barrel. In 1909 there were 103 Portland cement plants in operation, an increase of five over the number working in 1908. Of these plants 21 were in Pennsylvania, 12 in Michigan, 10 in Kansas, 8 in Ohio, 7 in New York, 6 in Indiana, 5 in Illinois and 5 in California.

An experimental ore dressing and metallurgical plant of the Colorado School of Mines at Boulder, Colo., is now under construction. The building, when completed, will be 100 by 150 ft. There will be four sections, for sampling, concentration, milling and metallurgy. The plan will provide not only a laboratory for the school, but also a commercial size testing plant for the use of the mining industry, where ore in carload lots may be given exhaustive and scientific tests so as to determine the most economical method of treatment. The need of such a plant is evident to every one who is conversant with the actual mining conditions in the state.

The U. S. Civil Service Commission, Washington, D. C., will hold an examination on Nov. 9, 1910, to secure eligibles from which to make certification to fill vacancies as they may occur in the position of mining engineer in the Bureau of Mines, Pittsburg, Pa., at salaries ranging from $2,400 to $3,000 per annum, and in other branches of the service. Competitors will not be assembled for any of the tests. It is desired to secure persons having broad training and experience in mining ore, dressing and smelting, and in the treatment and preparation of coal, ores, and other mineral substances. They should be fully qualified to undertake original investigations into the causes of waste in mining mineral products and to suggest remedies therefor.

According to figures issued by the U. S. Geological Survey, the production of natural mineral pigments in the U. S. in 1909 exceeded that in 1908 by about 23 per cent; the value of the output exceeded the value for 1908 by about 14 per cent. The production in 1908 was 49,853 short tons, valued at $536,544; the production in 1909 was 61,137 short tons, valued at $613,133. The substances covered by these statistics are ocher, umber, sienna, metallic paint, mortar colors, ground slate, and ground shale, and the increase in output and value was confined to the four classes last named. Pigments made directly from lead and zinc ores were produced in the U. S. in 1909 to the value of $7,063,332, representing 87,525 short tons. The quantity and value for 1908 were 75,133 tons and $6,946,283. These pigments include sublimed white and blue lead, zinc lead, and zinc oxide, the last forming by far the larger part of the product.

THE LABORATORY

CARBON DETERMINATION IN STEEL BY MEANS OF THE ALLIHN FILTER TUBE.

By DR. PRETTNER.

(Translated from the German for the Chemical Engineer.)

In spite of the many rapid methods, the determination of carbon in steel by the separation of elementary carbon in the wet way and consequent burning of the carbon in a combustion furnace maintains its accuracy only through special care and manipulation. It is used in many laboratories for control and referee work. It would therefore be of interest to know that it is possible to perform the elementary carbon determination in much shorter time and especially with the abolition of the cumbersome, heating, expensive, and uneconomical combustion furnace, with the same degree of accuracy and with inexpensive, almost primitive apparatus.

This is made possible by filtering the carbon (obtained by the method of Ullgreen Sprenger viz: cooking the steel shavings with neutral $CuCl_2$ solution to which after ½ hr. $FeCl_3$ and then after 20 min. more some HCl (1.12) are added through an Allihn filter tube which is used later in the process as a combustion tube.

The trials at first were made without a quartz tube filled with CuO placed before the CO_2 absorption apparatus. The results of these and other trials are given at the end of the discussion.

Up to now only steels up to 1.20 per cent C have been examined by this method. The basis of the method is the ease with which the finely divided, amorphous carbon obtained from the steel by solution in $CuCl_2$ solution, will burn.

A determination of graphite in a cast iron containing 2.5 per cent graphite gave results 20 per cent too low. Decreasing the diameter of the combustion tube and the consequent increase in heat could perhaps remedy this.

The method is as follows:

The resolution containing the separated carbon is filtered through a numbered Allihn filter tube, made of potassium glass about 2 cms. diameter and 30 cms. long. Of this length 8 cms. is only about .8 cm. diameter. To prevent the asbestos layer (not over 1 cm. thick) from being sucked through, a small glass bead 0.8 cm. diameter is placed in the tube. The asbestos should be long fibered and well washed.

With steels containing over 0.5 per cent Si a few drops of HF should be added before filtration. With steels containing tungsten the solution should be allowed to stand 5-10 minutes and the settled WO_3 poured on the filter after the carbon. The beaker and rod are wiped with some asbestos, the mass is washed with 3-4 changes of hot water, sucked dry by the pump for about one minute, and then dried at 110-120°.

In the diagram "A" is the pressure bottle, "B" contains the oxygen, which flows through the cock "C" into a Dennstedt tower "D," where it bubbles through concentrated sulphuric acid in the base then through the soda lime and $CaCl_2$ in the tower. The gases are again controlled by the screw clamp "o," and then pass into the Allihn tube at the narrow end. From here the gases pass through the $CaCl_2$ tube "i" into the tube "H" of quartz glass about 30 cms. long, which is filled with spirals of copper oxide and is kept at a bright red heat. They next pass into the CO absorption apparatus "L" which is held by the wooden block "M." The end bottle "N" is filled with water, indi-

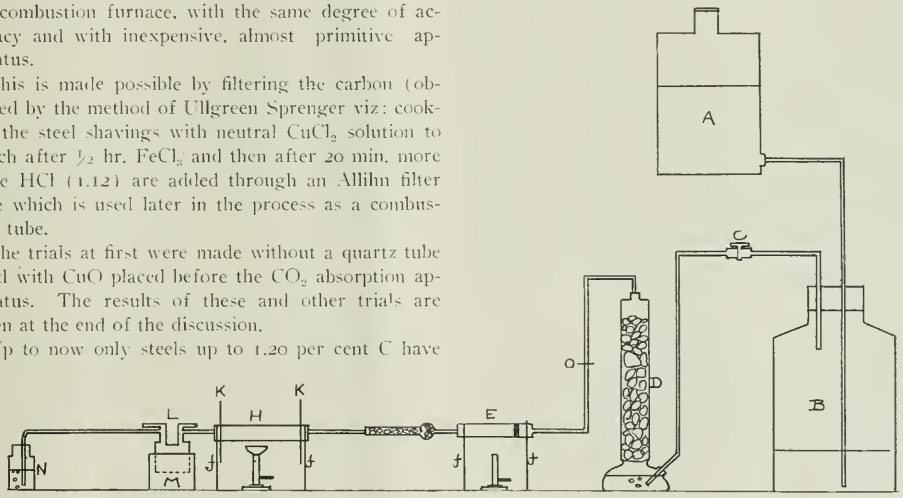


Diagram Showing Arrangement for Determination of Copper in Steel.

cates the rate of flow of gas and should be connected to "L" by a tube at least 60 cms. long to prevent any water from being sucked back into "L"; "f" "f" are supports cut out of sheet tin and lined on the burner sides with asbestos. They should be about 21 cms. high; g is a roof made of bent asbestos board which is placed over the Allihn tube during combustion. "KK" are asbestos sheets to protect the hose connections on the quartz tube "H."

A. Dennstedt CO_2 absorption apparatus is used which when filled with soda lime makes it possible to complete the absorption in ½ hr. The rapidity of absorption of this piece of apparatus, whose solid contents offer a large absorption area and good distribution of the gases over this area, is not yet realized in most laboratories. As a rule the fragile type containing KOH solution finds more favor although these are only able to absorb the CO_2 slowly. The two weighings of the absorption apparatus should be made on the same day. It should be handled only by the small tubes and the stopcocks should be opened to establish equilibrium.

Before the first combustion the apparatus should be filled with oxygen.

After the whole apparatus has been set up and tested for leaks, the oxygen is turned on slowly and the front part of the Allihn tube heated to a weak glowing, then the total heat is turned on the asbestos filter and the carbon will be ignited.

The burner flame is immediately turned off and the self combustion is regulated by means of the screw clamp "o" so that no carbon monoxide flame appear, which is a sign of too much oxygen and does not affect the results but causes a sucking back of the water in the end bottle "N." At the end of the asbestos filter is burned out by bringing it to a bright red heat and rotating the tube. The burning off the carbon takes at the most 5 mins. It is best to work in a rather dark room to better observe the progress of the combustion and not to heat the tube too hot, which is not necessary in this method. The tube is then cooled by a strong current of oxygen, the water level in the bottle "B" being noted. When this level has risen about 6 cms. in about 20 mins. one may be sure that the gases have been quantitatively driven over.

A new Allihn can now be connected in and it should be possible to complete the next combustion in 30 mins. The tubes after the combustion are ready for further carbon filtrations. This method allows a steady operation without much heat and is economical at the same time.

A combustion furnace with a porcelain tube, gasometer, and drying apparatus costs about 150M. The Allihn outfit will cost about 30M. The combustion furnace uses 2-2.5 cbm. gas per determination while the Allihn tube uses only .08 cbm. Many hundred determinations have been thus made in the laboratory of the Kgl. Gewehrfabrik at Spandau with perfect satisfaction.

TRIAL RESULTS.

The steel sample contained .618 percent carbon.

1. Combustion in regular combustion furnace	.618	.582	.617	.618 percent carbon
Combustion in Allihn tube using No. 1 CuO tube.				
a. using only air	.414	468		
b. using only oxygen	.508	.456	.509	.460
c. with the contact substance in the Allihn tube itself.				
a. copper oxide	.582	.565	.565	.580
b. plat. asbestos	.526	.543		
The last two tubes soon became unfit for use.				
3. Combustion in Allihn tube with CuO tube as per diagram	.609.	.596	.611	.615

A RAPID, PRACTICAL METHOD FOR THE DETERMINATION OF ANTIMONY AND TIN IN ALLOYS SUCH AS BABBITTS AND SOLDERS.*

By W. B. VIETZ.†

Genuine babbitts are nearly always hardened by means of copper and it is often desirable to have a quick method of estimating this copper as well as the antimony and tin in the babbitt. Solder into which copper "leads" of electrical coils are dipped takes up copper and it is essential when solder is so contaminated to be able to quickly estimate the amount of copper present as well as any antimony that may have been added to cheapen the solder or give it a better color.

In order to test for and estimate closely the small percentage of copper that may be present in such alloys, the following method was devised. It is a modification of the W. H. Low method, published in the *Journal of the American Chemical Society,* of January, 1907, which consists essentially in titrating in the same solution, first the antimony by a standard potassium permanganate solution and then the tin by a standard iodine solution. The details of the modified method are as follows:

Take 0.3 to 0.5 gram of fine drillings in an ordinary wide mouth thin glass flask (a round bottom pint flask is suitable) and add 10 or 15 cc. of concentrated sulphuric acid. Heat carefully over a bare flame until the alloy is all dissolved. It is convenient to use a wooden holder for the flask which is kept in constant motion while heating over a not too strong flame. Alloys with much tin dissolve readily while those with more lead and antimony require more boiling in the acid.

The various parts of the apparatus shown in the accompanying cut are as follows: 1. Coarsely broken

*From The Metal Industry.

†Assistant Chemist, Westinghouse Electric & Manufacturing Co.

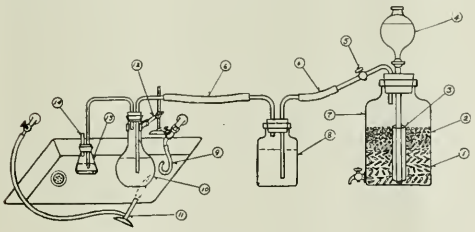
glass. 2. Marble lumps. 3. Glass tube. 4. L funnel for HCl. 5. Gas cut off. 6. Rubber tubing. 7. 5 Liter bottle. 8. Water wash bottle. 9. Hose for cooling flask. 10. 50 cc. flask solution of tin. 11. Gas burner. 12. Clamp support. 13. Water indicator, to show when any suction starts in main flask. 14. Steam escape.

COPPER DETERMINATION.

For the copper test let the sulphuric acid solution cool down somewhat and add 15 cc. of distilled water and 15 cc. of concentrated hydrochloric acid. Compare the color with that of a similar solution containing a known amount of copper. Approximately the same percentage may be put in a trial solder solution at the time by having a standard dilute solution of copper sulphate on hand. In making this color comparison it is essential, of course, to have all conditions the same as nearly as possible. The test is applicable up to 4 or 5 per cent of copper and it will be found that even 0.2 or 0.3 per cent of copper shows a distinct color in the hot and concentrated solution.

ANTIMONY DETERMINATION.

Having tested for copper, if necessary, dilute the solution to about 200 cc. and cool thoroughly. Titrate



Sketch of Arrangement for the Determination of Antimony.

with standard potassium permanganate for the antimony. The end point is a momentary pink coloration which is more fleeting and uncertain if too much hydrochloric acid is present. From 10 to 15 cc. of hydrochloric acid is enough.

If the potassium permanganate solution is made 1.59 stronger than one-tenth normal or 3.21 grams of potassium permanganate to 1,000 cc. of distilled water, then 1 cc. of the standard solution will equal 6 milligrams of antimony. On a 0.3 gram sample, simply double the burette reading for the percentage of antimony. Standardize the solution by using Kahlbaum's C. P. antimony in order to determine the correction, if any.

TIN DETERMINATION.

After the permanganate titration add to the solution about one gram of the Kahlbaum C. P. antimony and 25 to 50 cc. of concentrated hydrochloric acid, according to the amount of tin present. The antimony must be very finely ground in an agate mortar to be effective in reducing. Connect the flask with a carbon dioxide generating apparatus and heat the solution carefully by means of a moving flame and boil for two or three minutes (see cut for details of carbon dioxide apparatus).

Cool rapidly under the tap while passing a current of carbon dioxide into the flask to prevent the re-oxidation of the tin solution by the air and in order to counteract the back suction as the flask is cooled with the running water. As soon as cool add a little fresh starch solution and titrate rapidly by standard iodine solution, about one-tenth normal, until the liquid shows a blue-black color. Thirteen grams of iodine to 1,000 cc. of distilled water is a convenient strength, as 1 cc. equals approximately 6 milligrams of tin. Standardize against C. P. tin. Dissolve and treat in a similar way to that used in the analysis, as there is usually a small correction to be made depending on the various conditions. The results are reliable only when the process is carefully carried out. The titration of both the tin and antimony requires a little practice or acquaintance in order to judge the end point accurately. For many alloys, especially solders, these three rapid determinations of copper, antimony and tin, will also allow the approximate estimation of the lead in the alloy by difference. Where a great number of determinations are made it will be found a measure of economy after an analysis is finished to wash by decantation the antimony that is left. It can then be dried, reground and used again.

The impure tin oxide that is often obtained in gravimetric analysis of alloys, drosses, skimmings, etc., may be conveniently treated by the above method. In order to do this the calcined tin oxide is fused with equal amounts of sodium borate and sodium carbonate, the fusion dissolved in hydrochloric acid, then reduced with antimony and titrated with starch and iodine as before described.

Members of the American Iron and Steel Institute, who were in attendance at the annual convention held in New York, last week, visited in Chicago for an inspection of the various steel plants in that vicinity. Among the prominent guests were Colonel Sir Charles Allen, nephew of Sir Henry Bessemer and president of Henry Bessemer & Co. of Sheffield, England; Arthur Keen, of Guest, Keen & Nettlefold, perhaps the largest steel-makers in Great Britain; G. Scoby-Smith, managing director of Bolckow-Vaughn & Co., Ltd., Middlesborough, England; Sir John Randles, M. P., chairman, Moss Bay Hematite Iron and Steel Company, Ltd., Workington; S. J. Robinson, managing director, William Jessop & Sons, Ltd., Brightside Works, Sheffield, representing the Sheffield Chamber of Commerce; William B. Peat of W. B. Peat & Co., London; David Colville, managing director, David Colville Sons, Ltd., Motherwell, Scotland; T. Frame Thomson, chairman, Otis Steel Company, Ltd., London, and Herman Harjes of Morgan, Harjes & Co., Paris.

METALLURGY.

THE PHYSICAL PROPERTIES OF CAST IRON.*

There are many physical properties which are, or may be, of importance in iron castings. A list of the more important is as follows:

Static strength, including tensile strength, compressive strength, transverse strength, torsional strength, shearing strength.

Dynamic strength, embracing resistance to repeated stress, resistance to alternating stress, resistance to shock

Elastic properties, embracing elastic limit, resilience or elasticity, rigidity, toughness, malleability.

Hardness, embracing hardness of mass, ability to chill, hardness of chill.

Grain structure, including fracture of grain size, porosity, specific gravity.

Shrinkage, embracing shrinkage of the liquid mass, shrinkage of the solid mass, stretch.

Fuid properties, embracing fusibility, fluidity.

Resistance to heat, embracing resistance to continued heat, resistance to alternate heating and cooling, resistance to very low temperatures.

Electrical properties, including electrical conductivity, magnetic permeability, hysteresis.

Miscellaneous properties, including resistance to various corrosive agencies, resistance to wear, coefficient of friction.

In addition to this list, which gives the properties of the metal substance, the following properties of the mass, as a whole, are important:

Soundness, or freedom from blow-holes and shrinkage cavities.

Cleanness, or freedom from inclusions of dross, etc.

Freedom from pinholes and porous places.

Homogeneity, or lack of segregation.

Crystallization.

Freedom from shrinkage strains.

Tendency to peel off sand and scale.

We will now consider, one by one, each of these properties in relation to chemical composition in every case where any relation is known.

Although in our list we have enumerated several different kinds of strength, we now find it convenient to treat the subject in general. As regards chemical composition there are nine factors which influence strength of cast iron. Per cent. graphite; size of individual graphite flakes; per cent combined carbon; size of primary crystals of solid solution FeCSi; amount of dissolved oxide; per cent phosphorus; per cent sulphur; per cent silicon; per cent manganese. In addition to these factors there are probably some others which influence strength, since we not infrequently find considerable variation which cannot well be attributed to any of the above.

The weakening effect of graphite is due to its own extreme softness and weakness, and to the fact that it occurs in small flasks or plates, and hence affords a multitude of cleavage planes through the metal. The size of the graphite particles is evidently important as well as the amount, but this factor will be discussed under another head.

Theoretically, the simplest method of decreasing graphite is to lower the silicon, each decrease on 1 per cent in silicon lessening the graphite by 0.45 per cent, provided the total carbon remains the same. Practically, however, the fact that all the carbon, not graphite, becomes combined, is an important objection, for when we lower the silicon too much the resulting increase in combined carbon increases the hardness, and beyond a certain point, decreases the strength. The minimum permissible silicon will depend chiefly on the hardness allowable.

The same objection applies to decreasing the graphite by increasing the sulphur and manganese, and in the case of sulphur there is also the objection that its direct effects are injurious. The rate of cooling is, of course, beyond the control of the foundryman in the majority of cases, while even if it were not, the graphite could not be reduced by rapid cooling without a corresponding increase in combined carbon.

Coming finally to the total carbon we find here a means of reducing graphite without in any way affecting carbon, and hence, hardness. The only limitation to this is that as total carbon and graphite are reduced shrinkage is increased and the metal becomes more liable to oxidation, blow-holes and other defects.

There are three ways of reducing total carbon in castings: First, by the use of low carbon pig iron; second, by melting in the air furnace; third, by the use of steel scrap in the cupola mixture.

The pig irons lowest in total carbon are, as a class, the charcoal irons, especially those made with cold blast, and these irons are also, as a class, the strongest, although not entirely because of their total carbon. To get the full benefit of this iron, it should be melted in the air furnace, but with careful attention to details very good results may be obtained in the cupola also.

In air furnace melting it is easy to reduce total carbon to almost any figure within reason; 2.75 per cent is commonly obtained in melting for malleable castings. Of course the silicon is also burnt out during this process, but were it desired, this could be readily

*Paper by John J. Porter, presented at the Detroit convention of the American Foundrymen's Association.

replaced by suitable additions of ferro-silicon. From the standpoint of quality the air furnace is certainly the ideal method of melting, and hence, we find that many lines of castings which must be of particularly high quality are invariably made from air furnace metal.

The addition of steel scrap to the cupola has now become common practice, the product obtained being known as semi-steel and differing chemically from ordinary cast iron only in being somewhat lower in total carbon and graphite. Physically, the metal so made is characterized by greater strength and total shrinkage, hardness remaining about the same. While the process of making a superior metal from a mixture of cast iron and steel has been known for a long time, dating back to Sterling's patents in 1846, there are still many who hold that a satisfactory semi-steel cannot be made by melting in a cupola. Certainly there are many difficulties in making it in this way but the success with which it is done shows that these are not insurmountable.

The chief points to be watched in melting steel scrap in the cupola mixture are as follows:

Blowholes.—These are due to the fact that semi-steel, being lower in carbon, oxidizes more readily than cast iron. The trouble may usually be overcome by correct cupola practice and the use of ferro-manganese or other deoxidizers in the ladle. Owing to the higher melting point of semi-steel mixtures, ferro-manganese is much more efficient as a deoxidizer here than in the case of cast iron. It is said that wrought iron scrap is the frequent cause of porosity in castings, possibly because of the considerable amounts of iron oxide which it contains in the form of slag fibers.

High Shrinkage.—This is due to the decrease in graphite and is hence inevitable. On work where this is an important factor a proper balance must be struck between shrinkage and strength.

Imperfect Mixture of Steel and Iron Resulting in Irregular Quality of Casting, Hard Spots, Etc.—This results from the higher melting point of steel and consequent difficulty of getting perfect solution in the cast iron. It may be largely overcome by careful attention to the charging of the cupola, placing the steel scrap on the coke and the iron on top of the steel so that the latter will reach the melting zone first and the molten pig will run down over the heated steel instead of away from it as would happen if the order were reversed. A large receiving ladle should, of course, be used also. Another point to be observed is in regard to the size of the steel scrap. Too large scrap is difficult to melt, but, on the other hand, very small scrap is also objectionable as being an abundant source of hard spots in the castings. Apparently, very small pieces of steel are liable to be washed down through the coke bed and out of the cupola spout without being completely melted. Finally, it is said that high carbon steel is much more difficult to melt and alloy with cast iron than low carbon material. This is exactly contrary to what we should expect from theory, but is so confidently maintained by competent foundrymen who have made the experiment that it is thought best to call attention to it here.

Absorption of Carbon in the Cupola.—Of course a metal non-saturated with carbon, when melted in contact with coke as in the cupola, will take up carbon, tending, if time be allowed, to become saturated. It has been urged, therefore, that the melting of steel in the cupola nullifies all the advantages of the use of this mixture. This criticism is only partly true, however, for under suitable conditions of cupola practice, only a comparatively small amount of carbon will be taken up by the steel and the total carbon in the resulting molten metal will be materially lowered. To accomplish this end, the tuyeres should be low and the iron allowed to run from the cupola spout as fast as melted. While it is advisable to use enough coke to get a good, hot metal, still, the less excess above that amount the better, from the standpoint of carbon absorption.

Regarding the amount of steel scrap to use it has been found by trial that the best results are obtainable with about 25 per cent. Increase to 33⅓ per cent caused a slight falling off in strength. Probably these figures would not hold for every condition of practice but, in general, 20 to 30 per cent steel is a sufficient amount to give the maximum results.

The size of the graphite flakes is probably the most important factor of all those which influence strength and is the one which most frequently upsets our calculations as to the relation between chemical composition and strength. The fact that this factor is one to be considered has been appreciated in a general way for a long time, whence the so frequently used expression "close-grained," "strong iron," etc. Recently, however, F. J. Cook and G. Hailstone have brought out, in a striking manner, the great difference in irons in this respect. They give data showing that of two mixtures, practically identical in composition, the one was invariably much lower in strength, usually about one-half, than the other, this being the case for a great many heats extending over a long period of time. The following analyses and tests are given as typical of the series:

Tensile test.	Series A. 18,200 lbs. per sq. in.	Series B. 36,600 lbs. per sq. in.
Total carbon	3.250	3.092
Graphitic carbon	2.397	2.280
Combined carbon	0.853	0.903
Silicon	1.328	1.314
Sulphur	0.095	0.101
Phosphorus	0.023	0.090
Manganese	0.290	0.335
Iron by difference	94.114	94.149

Messrs. Cook and Hailstone have investigated and compared the micro-structure of the strong and weak bars and record two interesting facts: First, that the graphite flakes are invariably much larger in the weak bars; second, that when the polished specimens are

treated so as to bring out the phosphide eutectic this eutectic is seen to be arranged in the customary heterogeneous manner in the weak bars, but in a distinct mesh-work structure in the strong iron. These authors draw the conclusion that it is this mesh-work structure which gives great strength to cast iron, but with this conclusion the writer cannot entirely agree. It seems more probable that the increase in strength is caused by the fine state of division of the graphite and that the same influences which have caused this have also caused the meshwork structure.

We may get some idea of the quantitative relationship between strength and size of graphite by considering the relative strength of malleable cast iron and a very open gray cast iron representing the smallest and largest graphite respectively. Malleable cast iron has a tensile strength of 40,000 pounds and upwards per square inch, open gray iron about 20,000 pounds per square inch. Apparently, then, the increase in the size of the graphite has caused a loss of at least 20,000 pounds in tensile strength.

It is one thing to find that to get strong iron we must have the graphite in a finely divided state, and another and much more difficult matter to formulate rules whereby we may secure this desired condition. The writer has given much thought and study to this subject with but indifferent success as far as practical results are concerned. The following discussion, however, is believed to be the first systematic exposition of the subject and may, perhaps, aid others in following it up.

The factors which influence the size of the graphite flakes in cast iron are as follows:

A.—Factors which certainly exert an influence.
- *a.* Rate of cooling.
- *b.* Pouring temperature.

B.—Factors which may possibly exert an influence.
- *c.* Time which iron has remained in the molten state.
- *d.* Presence of dissolved oxide.
- *e.* Presence of steel scrap in the mixture.
- *f.* Mixture of different brands.
- *g.* Nature of ore from which iron is made and treatment in the blast furnace.
- *h.* Per cent metalloids.

Rate of Cooling.—The influence of rate of cooling is undoubted. We have to distinguish here, however, between the rates of cooling through different ranges of temperature. Evidently the graphite which is separated within the semi-liquid iron will have a much better chance to grow large crystals owing to the greater mobility of the medium in which it is formed, while that graphite formed within the solid metal will necessarily be in small particles. Hence, we see that it is the rate of cooling through the solidification range 2,200 to 2,000 degrees Fahr., which is of prime importance, and if we can check the formation of graphite through this range and then allow it to form in the solid metal at lower temperatures, we will have all the conditions for both the soft and strong iron. This is the principle of Custer's process of casting in permanent molds and the making of malleable castings is based on the same theory.

Pouring Temperature.—The pouring temperature also undoubtedly exerts an influence in the size of the graphite flakes, and hence, on the strength. The relation between them is, however, a matter of some dispute.

Keep finds that the coldest poured iron is invariably the strongest. Other investigators have stated that the hottest poured iron is the strongest, while Longmuir finds that iron poured at a medium temperature is stronger than when poured either very hot or very cold. Longmuir's experiments, by the way, are the only ones in which a pyrometer was used and the temperature of pouring measured in degrees. In the other cases the terms "hot" and "cold" are only relative and we have no basis of comparison between the different experiments. For this reason we may place the greatest faith in Longmuir's results.

It is probable that the pouring temperature affects the size of the graphite flakes indirectly through changing the rate of cooling through the solidification range. On this assumption the best results should be obtained from metal poured at as low a temperature as will suffice to give sound castings.

Of the other factors which I have named as probably exerting an influence on the size of the graphite flakes some are undoubtedly important while others may be entirely without effect, but which are which we cannot as yet say certainly. I can only give the reasons which led me to conclude each factor in the list.

Time which iron has remained in the molten state.—This might conceivably have an effect in the case of cast iron high in total carbon, since graphite separating in the liquid if poured at once, and this graphite is in the form of the large flakes known as *kish*.

Presence of dissolved oxide.—There is no direct proof that this affects the size of the graphite flakes. However, it is well known that addition of deoxidizing agents almost invariably improves the strength and it is barely possible that a portion of this may be due to change in the size of the graphite.

Presence of steel scrap in the mixture.—Although no exact data are at hand it is the common impression that the addition of steel scrap "closes the grain," which is equivalent to saying that it reduces the size of the graphite. It is not improbable that much of the strengthening effect of additions of steel is due to this action rather than to any lowering of the percentage of graphite.

Mixture of irons.—It is firmly believed by many foundrymen of the old school that a mixture of brands gives better results than a single brand of the same

chemical composition as the average of the mixture. Again, Outerbridge finds that the addition of silicon as ferro-silicon to the ladle increases the strength, whereas, the use of pig containing just that much more silicon would, if anything, decrease the strength. This, he explains by the statement that the ferro-silicon furnishes silicon in the nascent state. However, it is just barely possible that both of these cases might be accounted for by some influence of the mixing of dissimilar metals upon the crystallization of the graphite. Cook and Hailstone believe that the difference in strength of the two mixtures quoted by them is due to some inherent quality of the pig iron derived from the ores used or their manner of treatment in the blast furnace. This inherent quality may have some connection with the presence of oxygen or nitrogen in the metal. In the light of our present theories it is quite impossible to account for these differences in any other way, and yet there may be something else which has thus far remained entirely unsuspected.

Per cent metalloids.—This, we know, has a certain effect. For example, high silicon is likely to cause larger graphite as well as more of it. Phosphorus should, theoretically, cause larger graphite since it prolongs the solidification period in which large flakes are free to separate. Whether this is actually the case has not yet been definitely determined. Sulphur and manganese, in the language of the foundry, close the grain, and probably do diminish the size of the graphite as well as its amount.

In conclusion, we are forced to admit that we know very little about this important factor and for the best results must still rely largely upon the accumulated experience of the practical foundryman rather than on the scientific deductions of the metallurgical chemist.

According to Prof. Howe, the properties of cast iron are the properties of the metallic matrix modified by the presence of the graphite, but since this metallic matrix may be considered as a steel of carbon content equal to the combined carbon of the cast iron, we can predict accurately the effects of combined carbon by the use of the data on steel. In the case of steel it is found that the strength increases regularly with the carbon up to about 0.9 per cent, then remains nearly stationary up to about 1.2 per cent, above which it falls off slowly.

In the case of cast iron the strength is dependent upon so many factors besides combined carbon that it is almost impossible to determine by direct experiment the percentage of combined carbon giving the maximum strength. All indications, however, are that the highest strength is obtained with somewhere between 0.7 and 1 per cent combined carbon, which is in sufficiently close accord with the corresponding value for steel. We may, therefore, state tentatively that the maximum strength is obtained with 0.9 per cent carbon, all other factors remaining constant. This applies only to tensile strength and approximately to transverse. For compressive strength a somewhat higher value, probably about 1.5 per cent combined carbon, would be found to give better results.

Size of primary crystals of solid solution Fe-C-Si.—There is absolutely no data as to the effect of this factor on the strength of cast iron and it is only from analogy with steel that we give it a place in the list of factors influencing strength. In the case of steel it is well known that the heat or mechanical treatment and consequent size of grain are exceedingly important factors in determining the strength. Whether in cast iron the presence of graphite nullifies these factors or whether they still exert an influence remains to be determined.

TABLE GIVING ANALYSES OF A NUMBER OF STRONG IRONS.

Total carbon. Per cent.	Combined		Silicon. Per cent.	Sulphur. Per cent.	Phosphorus. Per cent.	Manganese Per cent.	Tensile strength, pounds per sq.in. Per cent.
	Graphite. Per cent.	carbon. Per cent.					
3.45			1.14			0.30	very high
3.20			1.09				very high
3.15	2.50	0.65	0.90			0.30	35,600
3.10	2.70	0.40	1.91	0.060	0.49	0.74	31,890
3.23	2.15	1.08	2.36	0.064	0.33	0.24	31,560
2.95	2.44	0.51	1.83	0.100	0.65	0.55	36,860
2.18	1.62	0.56	1.96	0.030	0.38	0.60	31,400
		0.36	1.29	0.060	0.56	1.00	36,400
		0.58	1.50	0.070	0.47	1.00	34,200
		0.52	1.13	0.060	0.41	1.33	33,600
		0.40	1.33	0.050	0.70	0.75	32,800
3.22	2.90	0.32	1.34	0.140	1.09	1.38	33,360
2.90	2.60	0.30	1.63	0.120	1.10	1.29	30,400
3.09	2.31	0.78	1.31	0.080	0.29	1.51	36,920
3.09	2.29	0.90	1.31	0.101	0.91	0.33	36,600
3.23	2.68	0.55	1.96	low	low	low	33,376
3.25	2.75	0.50	2.19	low	low	low	34,944
3.20	2.50	0.70	1.25	0.070	0.70	1.00	high
3.00	2.28	0.72	1.31	0.056	0.66	0.43	35,430
			1.66	0.065	0.70	0.90	36,000
			1.60	0.063	0.72	0.85	37,300
			1.70	0.075	0.70	0.75	30,400
			1.70	0.075	0.60	0.92	31,300
3.07	2.44	0.63	0.94	0.050	0.44	0.31	31,350
2.50	1.40	1.10	1.00	0.050	0.30	0.60	33,000
3.52	3.10	0.42	1.53	0.050	0.29	0.45	30,000
1.71	0.96	0.75	0.98	0.060	0.43	0.43	34,700
3.18	2.05	1.13	1.19	0.055	0.41	0.42	37,100
3.00	1.62	1.38	0.71	0.058	0.54	0.39	30,100

Effect of dissolved oxide.—The influence of oxygen in cast iron is probably a much more important factor than is generally supposed, but there is absolutely no data on which to base a quantitative estimate of its effect. To reduce oxide in cast iron to the minimum, the following points may be observed: First, get the best brands of pig iron. It is probable that pig made with charcoal fuel contains less oxygen than

that made with coke fuel. Cold blast pig is better than hot blast. Pig iron made from easily reducible brown or carbonate ores is lower in oxygen than the pig made from red hematite or magnetic ores, while iron made from mill cinder should never be used in foundries where strength is a prime consideration. Moreover, a pig iron high in manganese is apt to be comparatively free from oxide because of the deoxidizing power of manganese at the high temperature of the blast furnace. It is noteworthy as confirming these observations that most brands of iron which have achieved a reputation for strength are high in manganese and many of them are charcoal irons. The Muirkirk and Salisbury brands, which have been known for years as among the strongest irons made in this country, answer to every one of these conditions. They are made from readily reducible ores using cold blast and charcoal fuel and contain from 1 to 2 per cent of manganese.

Second, avoid oxidizing conditions in the cupola, particularly high-blast pressures and wrong methods of charging. Dr. Moldenke's system of using small charges is to be highly recommended in this connection.

Third, deoxidizing agents may be used, added either to the cupola or to the metal in the ladle. Of the commercially available deoxidizers ferro-titanium, ferro-silicon and ferro-manganese are, perhaps, the most successful, all things considered.

Phosphorus lessens both the dynamic and static strength, but the former more than the latter. It weakens because it forms with iron a hard and brittle compound which has but little resistance to shock. The weakness produced is in nearly direct proportion to the amount of this compound present. The effects of phosphorus on strength do not become marked until upward of 1 per cent is present, but for great strength and particularly strength to shock it should be much lower. Ordinary strong irons may have up to 0.75 per cent, while iron which is to withstand shock should not exceed 0.50 per cent and is better even lower. Most "strong" brands of iron are moderately low in phosphorus, for example, Muirkirk contains about 0.3 per cent.

Many tests have been made showing that sulphur has no marked effect on strength and many foundrymen will use sulphur to harden iron and close the grain. It is true that an indirect strengthening effect can be obtained through the use of sulphur in some cases. If too soft an iron is being used the strength will be increased by the addition of any element which will lessen the graphite, but the hardening is usually better obtained through decrease in silicon than through increase in sulphur. While increased sulphur may not always show in decreased strength of test bars, yet it is a frequent source of blow-holes, dirty iron and the various defects caused by high shrinkage, hence, it often causes an indirect weakness in the iron.

These elements act chiefly in an indirect manner and because of their effects on the condition of the carbon. Their direct influence in the strength of the metallic matrix is unimportant. From analogy with steel it is probable that silicon in amounts of over 1 per cent causes weakness and brittleness in the metal. Similarly manganese has probably a weakening effect due to its direct action when present in amounts of more than 1.5 per cent.

The preceding discussion is summarized in the following practical rules for making strong castings:

Use strong brands of iron.
Charcoal irons if cost will permit.
Irons made from easily reducible ores.
Irons high in manganese.
Avoid oxidation in melting.
Look carefully after the details of cupola practice.
Avoid oxidized scrap.
Use deoxidizing agents in ladle if practicable.

Keep the silicon down as low as possible and still have the necessary softness. About 1.50 per cent will be right for the ordinary run of medium castings. Higher for small castings and lower for heavy ones. With low total carbon high silicon has less effect.

Keep the phosphorus low, especially when sulphur is high, 0.50 per cent or under is best.

Keep the sulphur low, especially if phosphorus is high. Under 0.10 per cent is all right for most castings.

Keep the manganese high, 1 per cent for large castings, 0.7 per cent for medium, 0.5 per cent for small castings.

Use from 10 to 25 per cent steel scrap in the mixture.

Keep recommends using 10 per cent cast iron borings charged in wooden boxes. He states that this is very effective in closing the grain and strengthening the castings.

For iron which is required to have the greatest possible resistance to shock, the points to be especially observed are as follows:

Keep the phosphorus as low as practicable, still having the necessary fluidity. It should best be below 0.30 per cent.

Keep the sulphur as low as possible.

If practicable add vanadium or titanium to the ladle, either in the form of a ferro-alloy or as thermite.

The accompanying tables gives the analyses of a large number of strong irons collected from many different sources. Attention is particularly called to the fact that the total carbons average quite low and the manganese is, with very few exceptions, quite high.

The granulated slag from blast furnaces is being utilized in Germany for the manufacture of brick. The making of slag brick is no new thing, but heretofore fluid slag has been employed for the purpose, and the brick thus produced has been found unsuitable for building purposes, because of its impermeability to air and steam.

The CHEMICAL ENGINEER

HARRY McCORMACK, Editor.

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NOTES AND COMMENTS.

The committee on engineering education, appointed by the American Institute of Chemical Engineers, has recently published a bulletin expressing some of their opinions on the education of the Chemical Engineer. The Chairman of the committee after having outlined existing conditions in our technical schools as he sees them, and giving the outlined course of a typical American university asks various chemical engineers to reply to the following questions:

1st. Is, in your opinion, a chemist having completed a four-year course as offered at this university and possessing the degree of B. S. satisfactorily equipped to enter practical work?

2nd. If question 1 is answered in the negative, can, in your opinion, a four-year course be arranged in such a way that a chemist after its completion is satisfactorily equipped to take up practical work?

3rd. If questions 1 and 2 are answered in the negative, can, in your opinion, a four-year course supplemented by one year post-graduate work taken at the same university equip a chemist to be efficient for practical work?

4th. Are the post-graduate courses as offered at American universities, in your opinion, the most effective courses which can be designed for the education of chemical engineers?

5th. If question 4 is answered in the negative, what changes are, in your opinion, necessary to make the offered courses effective?

6th. Are the courses offered at European universities and polytechnic schools, in your opinion, the most effective courses for producing chemical engineers, fit for work in American places of manufacture?

7th. Have you any specific suggestions for improving the courses, which are offered at present by American universities?

Only a small number of replies to these questions are printed, these replies being altogether from chemical engineers, and not from persons engaged in educational work. The consensus of opinion is that a chemist having completed a four-year course which is outlined in the committee's report as being offered by a typical American university as a course in Chemical Engineering is not satisfactorily equipped to enter practical work.

On the second question there is a difference of opinion, some contending that the course could be so arranged as to give the proper training in the four years. The greater number of replies, however, are to the effect that four years is not sufficient and should be supplemented by at least one year post graduate work.

The answer to the fourth question is that the post graduate courses as offered at the American universities are not the most effective courses which can be designed for the education of the Chemical Engineer.

The fifth question, of course, brings out a variety of answers. Nearly every chemical engineer has a different opinion as to the work which is the most important.

Question 6 is answered mainly in the negative.

Question 7 also has a large number of different answers.

The best suggestion is that one which is now being carried out in some of the better schools is one embodied in the reply of Mr. F. G. Wieschmann of St. Louis.

Quoting from his reply,

"I have not been able to give sufficient thought to enable me to outline completely the courses of study which should be included in the post-graduate year for chemical engineers, but proceeding upon the belief that chemical engineering is essentially the adaptation of laboratory processes to factory conditions, I believe that these courses should include the study of theoretical and practical electrochemistry, the designing and laying out of factories and the study by each student of some one industrial process along the lines in which he might be especially interested; for instance, in the manufacture of steel or of some other metallurgical process, the manufacture and dyeing of textile fabrics, in the refining of oils, in the refining of sugar, in practical ceramics and in the manufacture of pharmaceutical products, etc., etc.

"Of course, you will understand that these are merely suggestions, and can as yet be given only in a tentative way. That the proposition before us is a large one and will require a great deal of patient study, of course, I thoroughly appreciate."

Through an oversight the name of the author of the article "Alloys of Nickel and Cobalt With Chromium," published in our last issue was omitted. The author of this excellent article was Mr. Elwood Haynes.

LETTERS TO THE EDITOR.

THE TRAINING OF THE CHEMICAL ENGINEER.

Sir: I desire to state that your idea to put on record the thoughts of those individuals who are connected, more or less intimately, with the education of the Chemical Engineer, appeals to me as one of the most important steps necessary to a logical solution of this question. It is the desire that this discussion be

as general and complete as possible that prompts me to present my ideas.

As you state, in the past the chemical engineer has been trained in college either as a chemist or as an engineer. And the deficiency in his collegiate training he has had to make up by experience acquired after graduation. It is the desire to determine what a collegiate course in Chemical Engineering should include in order to present to the industrial world a well balanced chemical engineer, not a chemist only, or an engineer only, that this discussion was provoked, I take it.

Of course such a discussion will have two sides; the one advocating a maximum of work in chemistry and physics with but a minimum of work in the engineering subjects, the other exactly the reverse. It is evident then that the conclusion of such a discussion will be in the nature of a balanced action, an equilibrium between the two opposing reactions. Now it seems to me that it is the determination of this equilibrium point which immediately concerns us. In the determination of this point there are several factors to be considered, not the least of which is exactly what is implied by the term "Chemical Engineer." It can be easily seen how important the point of view is in such a discussion as this. In fact I believe that the point of view is the whole thing to this discussion.

I believe, with you, that "the chemical engineer must have a thorough foundation in the principles of inorganic and organic chemistry," and that "he must have considerable training as an analyst." But exactly how much time is required to impart this "thorough foundation" and this "considerable experience?" There are authorities who bewail the fact that four years devoted to chemistry alone is all too insufficient to accomplish this result. And when we see that in addition to the usual work in chemistry the chemical engineer must have considerable work in industrial chemistry and metallurgy, the question of how to get in the engineering subjects is more of a problem than ever.

Personally, I am of the opinion that it cannot be done in a four year's course, *as it should be done*. Our men will meet in competition the graduates of the continental schools. And I do not think it fair to presume that we can do in four years what they are doing in six. I do not mean for a moment that our men are afraid of such competition. What I do mean is that the ultimate objects of professional training should be to develop investigators. I think that this is essential even for executive and administrative work. But I do not believe that it is possible to develop such an investigator in four years. A fine foundation can be laid. But there is no time for original work. Hence our men, as they are trained at present, will have a tremendous handicap to overcome in competition with the men who are trained in Europe, most of whom have the equivalent of six or seven years collegiate and post collegiate work.

Conditions, at present, in this country do not necessitate so extensive a preparation. The four year course seems to be sufficient. The point I desire to make is this: that while the four years' course is sufficient just now, it is only a question of time, and in my opinion, a comparatively short time when such a course will be insufficient. Therefore I believe that this discussion should take cognizance of the fact, and further that our course should be made elastic enough so that the transition can easily be made.

All of this may be considered ideal at the present moment, but to me the necesity for such a lengthening of our courses seems to be sufficiently near, to make the idea very real indeed.

Yours respectfully,

B. B. Freud.

RECENT PATENTS.

The following patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill Bldg., Washington, D. C.

969,159. Method of Treating *Glycerin*. Samuel Henry Fleming, Camden, N. J., assignor to E. I. du Pont de Nemours Powder Company, Wilmington, Del., a corporation of New Jersey. Filed May 27, 1909. Serial No. 498,749. Patented Sept. 6, 1910.

969,202. Process of Making *Plastic Material*. Wm. R. Seigle, Nashua, N. H. Filed Dec. 20, 1909. Serial No. 534,186. Patented Sept. 6, 1910.

969,252. *Pyrotechnic* Compound. Bernard J. Dever and Bertram J. Delzeit, Philadelphia, Pa. Filed Oct. 25, 1909. Serial No. 524,513. Patented Sept. 6, 1910.

This is a process of separating metals from a mixture of the same and impurities which consist in mechanically feeding the mixture down a tube having its lower end submberged in molten metals and permitting the impurities to rise to the surface.

969,263. *Dental Flask*. David Folb, New York, N. Y. Filed July 16, 1909. Serial No. 508,068. Patented Sept. 6, 1910.

969,381. Process of Making Artificial *Cyrolite*. Gerhard Loesckann, Hanover, Germany. Filed Nov. 30, 1908. Serial No. 465,190. Patented Sept. 6, 1910.

969,432. Composition of Matter Used as an *Interior Finish* for Walls or Ceilings. Wm. H. Whitney, Jr., and Chas. W. Griffin, Brooklyn, N. Y. Filed Apr. 11, 1910. Serial No. 554,646. Patented Sept. 6, 1910.

969,504. Manufacture of *Briquets*. Ernst Trainer, Langen, and Wilhelm Haage, Walsum, Germany. Filed Dec. 13, 1909. Serial No. 532,948. Patented Sept. 6, 1910.

969,635. Process of Separating the Products of the *Destructive Distillation of Wood*. Thos. H. Kennedy and Fred J. Heckel, Bradford, Pa.; said Heckel assigner to said Kennedy. Filed Jan. 6, 1910. Patented Sept. 6, 1910.

969,661. Process of Generating *Formaldehyde*. Hans Schneider, Hamburg, Germany. Filed March 7, 1908. Serial No. 419,734. Patented Sept. 6, 1910.

969,773. Process of producing *Alloys* and the Separation of Metals. Percy Foote Cowing, New York, N. Y. Filed Nov. 11, 1909. Serial No. 527,407. Patented Sept. 13, 1910.

969,833. Production of *Ferric Salts*. Anson G. Betts, Troy, N. Y. Filed Jan. 7, 1909. Serial No. 471,120. Patented Sept. 13, 1910.

The process consists in oxidizing in solution a ferrous salt of a polybasic acid to a ferric salt, by electrolyzing the solution with an insoluble anode while maintaining the said solution at a temperature between 50° and 100° C.

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THE RECOVERY OF BY-PRODUCTS FROM PEAT.

By R. W. HILGENSTOCK.*

The development of the industry of recovering peat and its by-products in the marsh districts in northern Germany, especially East Friesland, has reached such a stage that there is no doubt now that it will be a well-paying investment. A good deal in this development is due to the interest, which the government has taken in this matter. In order that the different processes now in use should receive as wide a publicity as possible, Professor Hegenscheidt of Berlin was sent to Hannover to read at the Technical High School of that place a series of papers, dealing with this subject.

To understand thoroughly the apparatus for recovering the by-products of peat, which will be described later on, it is desirable to show first the composition of the peat. The following figures represent analyses of peat taken from different layers:

	NH_3	Acetic acid.	Methyl alcohol.	Gas oil.
Upper layer	0.187%	0.296%	0.171%	1.148%
Middle layer	0.393%	0.286%	0.197%	1.136%
Lower layer	0.181%	0.161%	0.119%	0.913%
Upper layer	0.322%	0.179%	0.158%	1.220%
Middle layer	0.334%	0.261%	0.156%	0.946%
Lower layer	0.194%	0.174%	0.106%	1.012%

From a destructive distillation of a mixed sample of the above peat the following products were obtained:

Coke = 31.11—39.13%, average 35.12%.
Tar = 1.46—4.12%, average 2.79%.
Tar liquor = 21.19—38.13%, average 29.66%.
Gas = 26.49—35.75%, average 31.12%.

The analysis, which was made of the recovered coke, showed a composition of:

C = 88.00%.
O = 5.00%.
N = 1.00%.
Ashes = 3.57%.
S = 1.02%.

A fractional distillation of the tar, recovered in the destructive distillation showed the following results:

Tar oil = 35.09%.
Paraffine oil = 55.12%.
Coke = 4.00%.
Gas = 4.03%.

The tar liquor contained the following substances:

Methyl alcohol = 0.740%.
Formic acid = 0.0015%.
Acetic acid = 0.95%.
Propanes = 0.001%.
Butyric acid = 0.0024%.
NH_3 = 0.350%.

*Engineer, Leipzig, Schleussig.

The composition of the gas as produced during the distillation is shown in the analysis below:

Carbon dioxide = 27.43%.
Oxygen = 2.23%.
Nitrogen = 2.25%.
Carbon monoxide = 8.60%.
Methan = 14.30%.
Sulphur = 1.00%.
Hydrogen = 23.60%.
Heating value = 2,700 calories = 10,700 B. T. U.

To show the variations in the composition of the peat in the different layers still more specifically, I will add the following analyses from peat of the Ochveter marsh and the Woerpdorf marsh:

Ochveter marsh.

Depth, Inches.	Dry Substance. Per Cent.	Ashes. Per Cent.	Carbon. Per Cent.	Hydrogen. Per Cent.
0—13/16	92.27	10.82	45.18	5.46
13/16—24	92.29	1.49	49.90	6.18
24—39	91.86	1.18	52.82	5.89
39—48	89.09	1.11	51.23	5.96
70—78	93.09	1.51	52.72	5.84
Wörpdorf marsh.				
0—3/8	99.22	7.00	46.29	5.86
3/8—15	97.33	3.72	48.60	5.73
15—38	95.17	1.31	48.97	6.18
38—48	93.29	1.36	49.90	6.35
48—60	87.28	1.33	49.34	6.25
60—72			51.82	6.05
72—82			52.37	6.05

The figures show clearly that the deeper the layer the higher the percentage of carbon and hydrogen in the peat, which as a consequence adds considerably to the heating value of the material, when we take into consideration that—

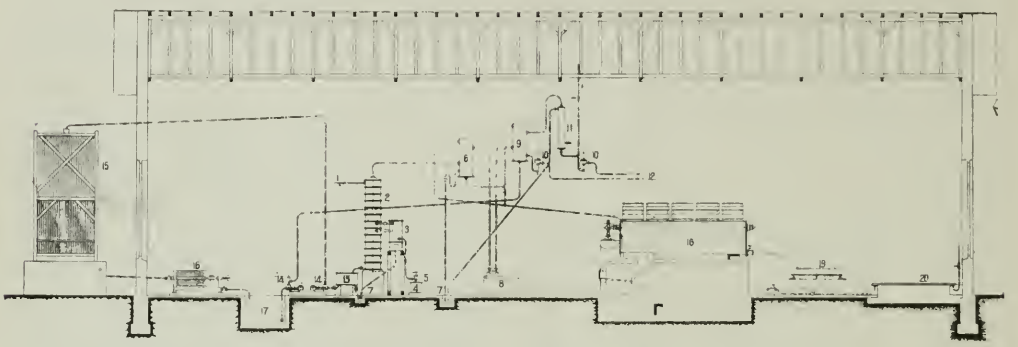
$C + 0_2$ develop 8,080 calories = 32,060 B. T. U.
$C + 0$ develop 2,473 calories = 9,800 B. T. U.
$H_2 + 0$ develop 34,462 calories = 137,800 B. T. U.

The works in East Friesland, now in operation, produce mostly briquettes of peat, which are used for heating purposes as well as for power purposes in gas producers in connection with gas engines. Of course, the peat as it comes from the ground has to undergo several separating, cleaning and crushing processes before it is fit for pressing it to briquette form. A description of the different machines to perform this would take too much space, and in fact does not belong in the scope of this article. They may be the subject for another description in another article.

The apparatus which is necessary to recover the principal by-products, ammonia, methyl alcohol and acetic acid, contained in the tar liquor is shown in the accompanying drawing.

The tar liquor, which is gained in almost the same way as the gas liquor in gas works, is pumped into a

high reservoir, which is provided with an ample size overflow pipe, to take care of the liquor, which is not taken by the still, so that the pump can always be in operation, which again secures a uniform pressure in the feed pipe. The liquor enters the still at 1; the still itself is practically the same as is used for gas house liquor and consists of three main parts, the sections for volatile ammonia, the liming leg and the sections for fixed or bound ammonia. In the upper seven sections of the still, No. 2, the ammonia which is not bound on acids is driven off by steam, which enters the still at the lowest section. In order to decompose the ammonia salts the liquor enters the liming leg, No. 3, where it is thoroughly mixed with milk of lime, which is prepared in tank, No. 4, and pumped into the liming leg by a pump, No. 5, which, in the drawing, is shown as a hand-pump. In larger plants of course it would be advisable to use a steam-driven pump, in order to have a steady stream of milk of lime go into the steam pump, No. 13, is connected. This pump serves the purpose of pumping the hot liquor on top of a wooden cooling tower or a graduation work for cooling it off and the so-treated liquor passes a filter press, No. 16, for retaining insoluble impurities, and afterwards flows into the cistern, No. 17. The vapors which leave the bell of the saturating box, No. 8, carry the methyl alcohol contained in the raw tar liquor and which had no chance yet to condense and to recover it. The vapors are still further cooled in the pre-cooler, No. 9. The filtered liquor, which is pumped from the cistern, No. 17, by pump, No. 14, serves as a means for cooling. From this pre-cooler the cooling liquor flows into the pre-heater, No. 6, and from here a pipe line carries it to the concentrating pan, No. 18. The vapors that leave the pre-cooler, No. 9, are finally and thoroughly cooled in an after-cooler, No. 11, which is fed by clear cold water to get a temperature as low as possible in order to recover the last parts of



Sketch Showing Apparatus for Recovering By-Products from Peat.

liming leg. The calcium oxide contained in the lime decomposes the sulphate, chloride and nitrate of ammonia, when these salts are present, and at the same time forms acetate of calcium $(C_2H_3O_2)_2Ca + H_2O$ with the acetic acid $C_2H_4O_2$ contained in the liquor.

Acetic acid will not distill over with the ammonia vapors, because its boiling point is at 112° Cels, and in as much as the temperature in the upper section of the still averages between 80° and 90° Cels, it would be lost when concentrating the waste liquor, as we will see later on, and to prevent this, sufficient milk of lime is injected to bind all the acetic acid. The mixture of gas liquor and milk of lime in the liming leg now enters the upper section of Part III of the still, where it comes in contact with the hottest steam and gives off its last particles of ammonia, which combine with the vapors of the upper part and leave the still on top, from where a pipe connects with preheater, No. 6. After leaving this apparatus the ammonia vapors enter the saturating box, No. 8, which is filled with sulphuric acid of about 42° Bé = Co 51% H_2SO_4. The waste liquor leaves the still at the bottom section and flows into a wrought iron tank, No. 13, to which a methyl alcohol which are contained yet in the vapors. Nos. 10-10 are glass-covered overflows for the methyl alcohol which travels through pipes, Nos. 12-12 to the rectifying stills, which are of the same construction as the ordinary stills for distilling alcohol. As noted before, the liquor leaving the pre-heater, No. 6, flows into the concentrating pan, No. 18, which is a cast iron vessel provided with wooden paddles and heated either by gas or a coal fire. The heating is continued until calcium acetate begins to crystallize out. When this point is reached the hot liquor is let off into the evaporating pan, No. 19, which is a cast iron vessel provided with a steam jacket and a good working steam trap. Here the liquor is boiled down entirely, and the residue, acetate of calcium, is finally dried on the steam-heated plate, No. 20, until it is entirely dry. The steam, which is used for this purpose, is then led under the evaporating pan, so that only a little fresh steam has to be added in this apparatus. The final product, calcium acetate, of course, still contains some impurities, and it is necessary to purify it further before it can be used and sold on the market, principally to dye works.

RECENT PROGRESS IN THE CHEMISTRY OF MERCERIZING.

By J. MERRITT MATTHEWS, PH. D.

In the chemical manipulation of textile fibers the process of mercerization is at present occupying an important position. From being a mere specialty mercerized cotton has now advanced to a recognized staple in the trade, and its production is not confined to a few manufacturers who formerly held it more or less as a secret process, for mercerization is now extensively practiced as a well-known and generally recognized finishing process.

There has been but little knowledge added of late to the actual process of mercerization itself, though some interesting work has been done with reference to the chemical properties of mercerized cotton. It has long been a well-known fact that mercerized cotton will absorb a greater amount of dyestuff than

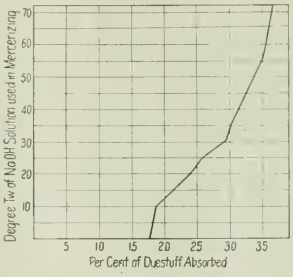


Fig. 1.

ordinary cotton, and Knecht[1] has endeavored to employ this reaction as a means of determining the degree of mercerization effected by different conditions, such as variation in the strength of the caustic soda solution, and variation in the time of treatment. I have plotted the following curves from the published results of Knecht on the absorption of Benzopurpurin by cotton yarns under different conditions of mercerization. On examining Fig. 1 it will be noticed that the degree of mercerization with variation in the strength of caustic soda increases rapidly up to a strength of 30° Tw., while beyond this point the increase is much more gradual, reaching a practical maximum at about 55° to 60° Tw. It would seem, then, that the use of caustic soda solutions of a greater strength than 60° Tw. offers no advantages in mercerizing. From Fig. 2 it will be seen that the mercerizing reaction is practically completed in a relatively short time. The degree of mercerization increases rapidly during the first 20 seconds of time, while from this point up to a time period of 60 seconds the increase in mercerization is very gradual, and reaches a practical maximum at about this point, for by continuing the time of treatment to 180 seconds the increase in degree of mercerization is almost negligible. This work

[1]Jour. Soc. Dyers' & Col., 1908, p. 68.

of Knecht confirms in a very definite manner the conclusions of earlier researches on this subject as well as the results obtained in the practical operation of the process. Hence, it may be considered as definitely established that the proper conditions for mercerizing are (1) to use a solution of caustic soda of 55° to 60° Tw. strength, and (2) the time of action of the caustic soda on the cotton should be from 1 to 3 minutes. Using stronger solutions or treating the cotton for a longer time does not materially increase the degree of mercerization.

Some interesting reactions of mercerized cotton have been discovered, whereby it can be rather readily distinguished from ordinary cotton. Hübner[2] recommends the use of a solution of 20 grams of iodine dissolved in 100 cc. of a saturated solution of potassium iodide. The sample of cotton to be examined is placed in this solution for a few seconds, and then washed. Ordinary cotton becomes a light chocolate color, whereas mercerized cotton becomes black. On further washing, the ordinary cotton will become

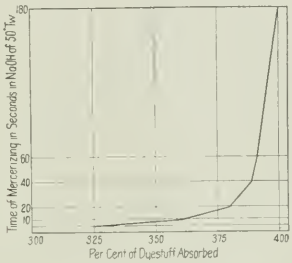


Fig. 2.

almost white in color, while the mercerized cotton will continue to remain a bluish black. Another qualitative test for mercerized cotton observed by Knecht[3] is based on the behavior of Benzopurpurin. Ordinary cotton when dyed with this red color is at once turned blue when treated with dilute hydrochloric acid, but mercerized cotton under the same conditions assumes a reddish violet color. Care must be exercised not to use too strong a solution of acid. If the acid solution containing the fiber is heated and a dilute solution of titanous chloride is added, the color on both fibers will gradually diminish in intensity, until just before the point at which complete destruction of the color occurs, the sample of ordinary cotton will show an indigo blue color, whereas the mercerized cotton will be red. It is said that this distinction is only to be noticed in samples of cotton which have been mercerized with caustic soda of more than 30° Tw. strength. This is an interesting point, for if reference be again made to Fig. 1 in the curve showing the degree of mercerization with different strengths of caustic soda, it will be noticed that at about 30° Tw. the character of the curve changes, evidently denoting a change in chemical condition. It would seem that in the action

[2]Jour. Soc. Chem. Ind., 1908, p. 105.
[3]Jour. Soc. Dyers' & Col., 1908, p. 67.

of caustic soda solutions on cotton, when a strength of about 30° Tw. is reached the cotton undergoes a chemical change which is not brought about by the use of weaker solutions of the alkali. This same fact appears to be demonstrated when we study the action of different strengths of caustic soda on cotton at different temperatures, employing the degree of contraction in the cotton as a measure of the degree of mercerization. This is illustrated in Fig. 3, in which curves are plotted for the different degrees of contraction when cotton is treated with caustic soda at different temperatures: the four curves corresponding to four different strengths of caustic soda Beltzer.[4] It will be noticed that between curves A and B (that is, between the results produced by solutions of caustic soda of 24° Tw. and 42° Tw., respectively) a distinct change in the character of the curve takes place, which we may assume as being likely at a mean of about 30° Tw., an interpretation which is entirely in keeping

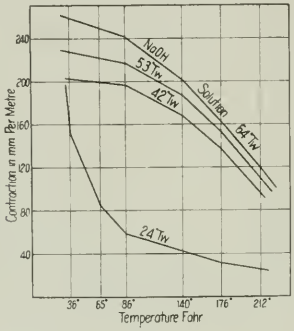


Fig. 3.

with that derived from an examination of the curve in Fig. 1.

Knaggs[5] has somewhat extended and simplified Knecht's reaction with Benzopurpurin, and recommends that the test be performed in the following manner: Samples of ordinary and mercerized cotton are boiled in a solution containing 100 cc. of water and 5 cc. of a solution of 0.1 gram of Benzopurpurin per liter. Then about 2 cc. of strong hydrochloric acid is gradually dropped into the boiling solution until the ordinary cotton has become blue black in color, when the mercerized cotton will appear red.

Supporting the view that in the mercerizing process the cotton undergoes a chemical change as well as a physical one, Wichelhaus & Vieweg[6] show that the cellulose of mercerized cotton gives a considerably higher yield of benzoyl ester than the cellulose of ordinary cotton; and though the percentage of nitrogen in the nitrates derived from ordinary cotton and mercerized cotton is the same, the products are chemically different, as the nitrate derived from mercerized cotton is more soluble in a mixture of alcohol and ether than that derived from ordinary cotton. Vieweg[7] further shows that cellulose of mercerized cotton is capable of combining with more sodium hydroxide than the original cellulose of ordinary cotton.

In the practical operation of the mercerizing process there has always been considerable difference of opinion as to the proper method of treating the cotton previous to its introduction into the mercerizing solution of caustic soda. The consensus of opinion appears to be in favor of a rather thorough boiling-out of the cotton with either dilute caustic soda or soda ash. In some cases, however, a simple passage through boiling water is deemed sufficient. At times soluble oils (turkey red oil, monopol oil, etc.) are employed, either alone or in connection with alkalies. Certain products containing malt, or substances capable of inducing a fermentation among the pectin matters in the raw cotton, have been advanced as material aids in the preparation of the fiber for mercerizing. Such a treatment is the so-called "merceranine" process which has been extensively advertised abroad, but which does not seem to have met with any degree of acceptance. Embodying somewhat the same idea is the method of first boiling-out the cotton in a dilute alkaline bath, and leaving it piled in a damp state overnight. In the warm, moist, alkaline condition, fermentation soon sets up in the pectin matters with which the cotton fiber is coated. This action probably aids somewhat in softening up the fiber and allowing of the more ready transfusion of the caustic soda solution in the mercerizing bath. The same condition is realized, however, more quickly and much more evenly, by the use of a small quantity of turkey red oil in the boiling-out of the cotton. The main idea in all these treatments is to obtain the cotton in such a condition that it may quickly and uniformly absorb the caustic soda throughout the mass of the fiber, and so become thoroughly mercerized. An interesting piece of research open in this matter is to definitely determine just what treatment previous to mercerization is necessary to yield the best results in practice, and thus aid in standardizing the method of procedure.

Another interesting feature in the chemistry of mercerized cotton is its behavior towards dyestuffs. It has been known in a general way for a long time that mercerized cotton had a much greater power of taking up dyes from solution than ordinary cotton, but the reason for this has been but little understood or investigated. It is also recognized in practice that it is much more difficult to obtain even shades in the dyeing of mercerized cotton than when ordinary cotton is used. This has generally been attributed to two causes: (1) the rapidity with which mercerized cotton takes up the dyestuff, thus not allowing sufficient time for the level dyeing of the color; and (2) uneven degree of mercerization throughout the material, some parts being mercerized more than others and consequently causing a variation in the amount of dyestuff

[4]L'Ind. Text., 1909, p. 112.
[5]Jour. Soc. Dyers' & Col., 1908, p. 112.
[6]Berichte, 1907, p. 441.
[7]Berichte, 1907, p. 3876.

absorbed. An interesting fact in this connection, however, is that when cotton is allowed to dry after mercerizing it will combine with much less dyestuff than cotton which has been mercerized and dyed without becoming dry. Also cotton which is only air-dried will take up more dyestuff than when dried at a temperature of 212° F. These facts, of course, have an important bearing in practice, for if cotton yarn which has been mercerized in either the warp or the skein is allowed to stand in the moist condition previous to dyeing, it is highly probably that portions of the yarn will become more or less thoroughly dried before dyeing takes place. Under these circumstances the yarn is very likely to color up unevenly, especially in delicate shades where the exhaustion of the dyebath is necessarily rapid and complete; for the dried portions will take up less dyestuff than the wet portions, and this will hold true even though the yarn is again completely wetted out before dyeing. In order to obviate this uneven dyeing it would be necessary to either dry out the mercerized yarn completely by putting it through a regular drying operation, or to take care that the yarn remains wetted all through and does not become dried out in places. In practice it has become a recognized method of procedure to completely dry the mercerized yarn before dyeing. Some interesting quantitative tests have been made in this connection by Knecht.[8] He determined by analysis (using the titanous chloride method) the amounts of Benzopurpurin taken up by mercerized cotton under different conditions of drying. His results were as follows:

	Dyestuff taken up. Per cent.
(1) Dyed without drying.....	3.24
(2) Air-dried before dyeing.....	3.03
(3) Dried at 110° C. before dyeing....	2.51
(4) Ordinary cotton (for comparison)..	1.77

It will be noticed that a considerable difference exists in the amounts of dyestuff taken up under the different conditions, and that the proper adjustment of these conditions would have an important bearing on the practical dyeing of mercerized cotton.

Another chemical feature in the modern process of mercerizing in a practical and economical manner is the recovery and regeneration of the caustic soda from the waste liquors. It requires from two-thirds to three-quarters of a pound of caustic soda (76°) to mercerize one pound of cotton yarn when working under supposedly the most economical conditions. This relatively large amount of caustic soda is practically all taken out of the yarn by the wash waters, consequently it becomes an object of considerable importance to recover this caustic soda, and, if possible, reduce the cost of the mercerizing process. In England, and on the continent of Europe generally, nearly all mercerizing plants are engaged in the recovery of their caustic soda, and under the conditions prevailing abroad, it is probable that unless this were done mercerizing could not be carried on as a paying investment. In this country, as yet, most places do not attempt to recover their waste caustic soda, but within the next few years this point of economy will have to be exercised in order to make mercerizing a profitable business. In England the recovery plants recover and purify about 90 to 92 per cent of the waste caustic at a cost of about one cent per pound, so they effect a saving on the cost of mercerizing of about three-fourths of a cent per pound of cotton. It must be borne in mind that the recovery of the caustic soda involves not only an economical concentration of the waste liquors by evaporation (usually with a double or triple vacuum effect), but also a purification of these liquors as well, for the mercerizing liquors become charged with a considerable amount of impurities taken out of the cotton. These recovered liquors also require a certain degree of re-caustization, as there is a considerable amount of carbonate formed during the mercerizing process. Treatment with lime and proper settling is the method employed. Under these conditions it is also best to make up the loss of caustic soda (about ten per cent by the formation of fresh caustic by the interaction of lime and soda ash during the process of purification. In this way it is not necessary to purchase any fresh caustic soda at all for the mercerizing.

Another important feature in the preparation of mercerized yarn which is extensively recognized abroad, but which as yet seems to have received but little attention in this country, is the treatment of the yarn after mercerizing to a lustering and softening operation similar to that given silk after dyeing. This treatment is given after the yarn is dried, and consists simply of stretching the yarn (in skeins) between two revolving and heated rollers enclosed in a steam chest to which live steam is admitted for a brief time. This operation increases considerably the luster and softness, or "finish" of the mercerized yarn, taking away from it that "wiry" character which it acquires during mercerizing, and which is one of its chief defects, thus restoring more elasticity and resiliency to the yarn. The cost of this extra process is very small, though the increase in the character of the yarn is very marked.

[8]Jour. Soc. Dyers and Col., 1908, p. 107.

According to a report of the U. S. Census Bureau over 4,000,000 cords of wood were used in the manufacture of wood pulp for paper making in the United States in 1909. This was an increase of about 650,000 cords of the consumption of 1908, but of only about 39,000 over 1907. The advancing cost of pulp wood of all species is clearly brought out in the report. The total consumption in 1909, though exceeding that of 1907 by less than 40,000 cords, cost over $2,000,000 more. The cost for 1909 exceeded that for 1908 over $6,000,000.

THE CHEMIST AND THE GLASS MANUFACTURER.*

By ALEXANDER SILVERMAN.†

For a number of years it has occurred to the writer that of all manufacturers the glass manufacturer seems least prone to take advantage of the valuable assistance the chemist has in his power to render. This power is naturally latent in most cases, but by proper co-operation on the part of manufacturer and chemist it could be made active and exceedingly valuable.

A few notes on the experiences of and results accomplished by a young chemist, employed for about one and one-half years in a factory where a large variety of glass was manufactured, will best serve as examples. This young man was one of ordinary ability, only, and while trained as a chemist had only that very limited knowledge of glass manufacture which can be gleaned from text books on introductory chemistry. In addition he had perhaps made a glass analysis or two.

September after graduation found him called to the factory already mentioned, where he was taken to a little four by six room, located in the basement, adjoining the mixing room, and told to establish and take charge of a chemical laboratory. The fallacy of this was, of course, evident to even a man of so little experience. He therefore immediately sought out the president of the company and succeeded in convincing him of the necessity of locating a laboratory and purchasing equipment. The chemist chose as a location a space next to the offices, and about the cleanest place in the plant. The superintendent was consulted and, never having employed a chemist, was perhaps somewhat suspicious, but finally succeeded in locating the laboratory next to his office in the mixing room, where soda ash and lime dust were constantly flying about. The floor of the laboratory was over a large open space, at one time used in connection with a producer gas plant but then filled with stagnant water. The ceiling consisted of brick arches, as it formed the floor of the factory above. A wooden ceiling was desired but not furnished, so instructions were left to paint walls and ceiling with zinc white, and the chemist left for several days to secure apparatus and chemicals necessary for equipment. A small still was asked for, but through the superintendent's influence the chemist was compelled to use condensed steam from the power plant. On returning the chemist found his laboratory white washed instead of painted. This he bore until dropping of plaster particles into beakers and crucibles became so frequent and spoiled so many analyses, that the president of the company finally ordered a modern ceiling installed. It was soon evident that steam from the power plant could not be used, so after purchasing distilled water for six months and finding its cost in excess of the still originally asked for this, also, was installed.

The first problem given the chemist was the production of a cloudy glass which would transmit subdued light without a fiery glare, and yet have a glossy surface. Several other kinds were already manufactured, but not as desirable. These were (1) glass whose surface had been etched with hydrofluoric acid, (2) sand-blasted glass, and (3) clear glass cased with opal. The first two of these had a dull surface on which dust accumulated, giving it a gray appearance, and the third imparted a fiery glare to the light. Besides, neither of these transmitted sufficient light, and each type required double handling in manufacture. The chemist was instructed to carry on this research work under the superintendent, who had already been trying two years to obtain the desired result. The superintendent would use clear glass batches, whose composition was unknown to the chemist, and the chemist had to recommend material to be added for the production of the desired cloudy effect. This state of affairs continued fruitless for about six months, when the chemist demanded the composition of the clear glass batch if he were to continue work on the problem. It was given him, and suffice it to say that in another six weeks he had produced this glass which for the past five years has been in demand for special lighting purposes, and were its properties better known it would generally displace etched, sand-blasted and opal glass. More light is transmitted than by either of the other varieties, the light is more nearly white and the appearance of the glass is decidedly pretty. A word regarding advantages to the manufacturer. The batch is workable after a short melting period, the glass has a high polished surface, and the slight difference in cost of raw materials more than counterbalances the cost of double handling involved in manufacture of either of the other three types mentioned.

Another branch in which this young chemist proved valuable was in the silvering department, where from 20,000 to 25,000 reflectors were produced weekly. The superintendent had been in charge of this department prior to the advent of the chemist, and his directions were "add a certain number of quarts of ammonia to a certain number of pounds of silver nitrate." The ammonia was kept in an open carboy, thereby constantly losing strength. It was measured in an open graduate and produced an almost unbearable atmosphere. The chemist's first step was to conduct the ammonia into the bottom of the silver nitrate solution by means of a syphon, the lower end of which was used as a stirrer through a rubber connection. He was thus able to secure a definite end-point and always have his silvering solution uniform, at the same time working in an atmosphere in which the odor of ammonia was hardly perceptible. After a little experimentation he found it possible to silver 26,000 reflectors perfectly from the same amount of silver formerly used for 18,000. The plant had for years turned out a number of spotted

*Paper read at the Pittsburg meeting of the American Ceramic Society, February, 1910.
†Pittsburg, Pa.

reflectors. The cause of this was discerned and the trouble entirely eliminated.

Through the analysis of raw materials used in glass manufacture a glass of more constant composition resulted. Lime, on being heated over the blast lamp, was found to contain from 12 to 32 per cent of volatile matter, depending on the shipment or length of time it remained in storage in the plant. Pearl ash, which readily absorbs moisture, had also to be corrected constantly.

In the plant referred to four or five types of glass were commonly worked. As there were generally about 20 of the 50 pots in use, it was necessary to check the glass so that no mistakes be made. The lone chemist found it impossible to conduct 20 such analyses daily, so he determined the specific gravity, and found that there was sufficient difference between the types to check each by its specific gravity. For this purpose a small piece of glass about the size of the first two joints of one's little finger was gathered from each pot, and the specific gravity determined by weighing in water and in air. This could be done in several minutes, thus affording a rapid check on composition.

These are a few of the things this young chemist accomplished, though entrusted with the formulæ of but two or three of the twelve or more batches mixed at that plant. At the end of about a year and a half he was dismissed because the company did not feel it could afford to increase his salary. What could not this young man have accomplished had he been given greater confidence by the firm employing him? Instead he drifted into other lines, as few glass manufacturers at that time employed chemists.

In the writer's mind, many important improvements would result were chemists more universally employed in glass factories. Expensive chemicals at present enter into the batch which might be partly or wholly eliminated. Processes might be almost revolutionized. Improvements might be made in colors and new colors added. New effects might be created in art glass. Economy might be effected in the purchase of raw materials, and new ones added to take the place of older and more expensive ones. One thing will, however, be absolutely necessary, and that is co-operation of the manufacturer with his chemist, and vice versa; they must display absolute confidence in each other. At present the superintendent of the plant is often czar because he understands the technical side from beginning to end, having worked in the factory from boyhood. He is usually poorly educated and refuses to co-operate with the chemist, who he thinks should confine himself to analytical work. If the superintendent is not in sympathy with the chemist's proceedings, and complaint is made to the manufacturer, the chemist is usually sacrificed.

One very important point which the manufacturer should bear in mind is that he cannot forever retain his chemist at a low salary. If the chemist is instrumental in reducing the cost of materials or manufacture, why should he not be given some consideration? This might be accomplished either by an increase in salary, or by leaving his salary stationary and offering a percentage of the profits as an inducement for further investigation along economic lines of manufacture. A good chemist who is properly appreciated in a manufacturing establishment is as valuable an asset as the manufacturer can acquire, and as long as given proper treatment the manufacturer need have no fear of losing any of his trade or manufacturing secrets. He takes a far greater risk in constantly changing chemists. The manufacturer should remember that the chemistry and principles of glass manufacture are meagerly dealt with in the great majority of universities, and that he has to reinstruct almost every new chemist he employs.

The writer's plea, therefore, is that the glass manufacturer employ a chemist and co-operate with him. Doing this, he can rest assured that in most cases he will be the one to profit.

A recent report of the Bureau of Mines of the Province of Ontario, Canada, shows that the output of the mines of Ontario for the year 1909, had a value of $32,981,375, an increase of 28 per cent over 1908, that year being the largest on record. Calculating the metallic products only on the market prices of refined metals, the valuation of the entire production is about 41 per cent of the total output of the Dominion. The results, so far obtained from the exploitation of Ontario's mineral resources, warrants the department in believing that in no other part of Canada is there greater metalliferous wealth than is contained in the pre-Cambrian rocks of the northern and eastern parts of Ontario. In silver, Ontario's production is third in quantity among silver-producing communities, being only surpassed by Mexico and the United States. Up to the present time there has been no indication whatever that the silver riches of Cobalt are approaching exhaustion. In some instances shafts have been sunk to a depth of over 500 feet without running out of silver ores. In no instance has it been demonstrated with any certainty how deep the silver really goes. Every year since 1905 the production of silver in Ontario has been rapidly increasing, and the high water mark is not yet in sight. Although Ontario now stands third among the silver-producing countries in the world, with the near prospect of soon outstripping all competitors in the production of nickel, Ontario is easily the first and Canada practically enjoys a world monopoly of this important mineral. Ontario also takes high rank for cobalt, arsenic, corundum and mica.

Other deposits of mineral industry continue to grow in output—natural gas, iron pyrites, feldspars and Portland cement.

THE PLANT.

INDUCTION FURNACE PROGRESS.*

BY T. ROWLANDS.

So much has been written on the induction furnace that it appears somewhat difficult to approach the subject without repeating numerous statements and facts. As this is the case, I must ask your indulgence, as I will be compelled to once more call your attention to certain particulars, but I hope to bring fresh points to your notice.

The history of the induction principle is now so well known that it is unnecessary to more than point out that the first commercial furnace was put into operation in 1902, at Gysinge, Sweden. During the past eight years great progress has been made, and now it is quite recognized that the application of the principle has been established beyond all doubt, as furnaces of comparatively high tonnage are in active operation. At the present moment 16 tons capacity per charge is regarded as the maximum, although there seems no doubt that furnaces of greater capacity can and will be designed as necessity demands.

THE SIMPLE INDUCTION FURNACE.

These are of the Kjellin-Colby design and intended for smelting purposes only, as the bath forms an annular channel in a crucible of suitable refractory material and the crucible is so designed to allow the center leg of the transformer, together with the primary coil, to pass through it. This is clearly shown in Fig 1.

These furnaces are built to take charges from 10 pounds to about 3 tons. The construction of furnaces of greater capacity has been developed into the combined or Rochling-Rodenhauser type.

This type of furnace is now running in competition with the crucible process for the manufacture of steel. Where power is moderately cheap, the cost of melting is very low as compared with the crucible process. It is only necessary to but casually look into the question and this point will be brought home with great force.

The best practice in the old coke method of melting, as followed in Sheffield, shows that fuel and crucibles alone cost about $14 per ton, and, in this country, using plumbago crucibles and working with gas producers, the cost is from $10 to $11 per ton.

If a medium-sized induction furnace, capable of melting about 4 tons per 24 hours, pouring only 1,000 pounds per cast and working on a high power consumption, is taken for comparison, and we allow a high cost for furnace lining, as follows:

750 kw. hours per gross ton at 0.5 cents per kw. hour	$3.75
Lining per ton	1.00
	$4.75

it will be seen that the saving effected on melting, for fuel and crucibles only, amounts to from $5 to $10 per ton.

The economy is even much greater, for, in the comparison, the power was taken at 0.5 cents, which is a high cost, and the consumption of 750 kw. hours is also very high; for, as it will be seen later, when melting regularly, the consumption for tool steels is much lower, but a high figure is given in order to allow for adjustment of compositions on making alloy steel, and also to allow for melting medium and low carbon steels. Then, again, the labor question has not been considered. Excluding the labor for the casting-pit, which is about the same in electric and crucible processes, the electric furnace hands are fewer, and it is quite the regular thing for one man and a boy to do all the work on a furnace tapping one ton each heat. The actual saving will be between $7 and $13 per ton of ingots.

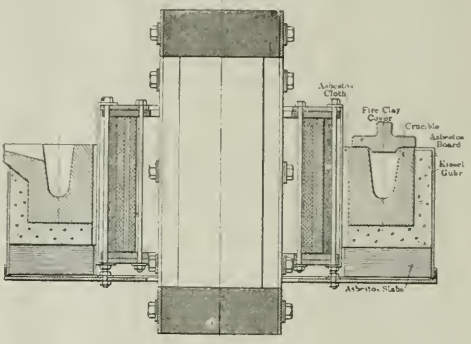


Fig. 1—Simple Design, Kjellin Induction Furnace (From Laboratory Type.)

The regularity of the composition of the steel is another factor in favor of electric melting. Any irregularity in the composition of the steel can be adjusted directly in the furnace before tapping. This, of course, cannot be so finely regulated in crucible practice. Bearing on this point, it would be as well to state the evidence given the writer by a friend, who has been operating in his department, a furnace tapping

*A paper presented at the 17th General Meeting of the American Electrochemical Society, at Pittsburgh, Pa., May 5-7, 1910.

about 3,000 pounds per heat. He stated that the only charge he found necessary to correct was the first one, as all the following charges were remarkably regular—always within a very narrow margin of the predetermined carbon percentage. High-speed and other alloy steels are just as regular, and the loss is very much less than in the ordinary method.

When operating a 150-kw. furnace at Niagara Falls, remarkable results were obtained. Several times the charge was ready within 1¾ hours from commencement of charging, and, on more than one occasion, in 1½ hours. Only on special occasions was the furnace pushed, for, as it was erected for demonstration purposes, the product was not marketed, but anyone who wished could have what steel he desired.

On one of the special occasions, a heat of over 1,000 pounds of 1.2 per cent carbon steel was charged and

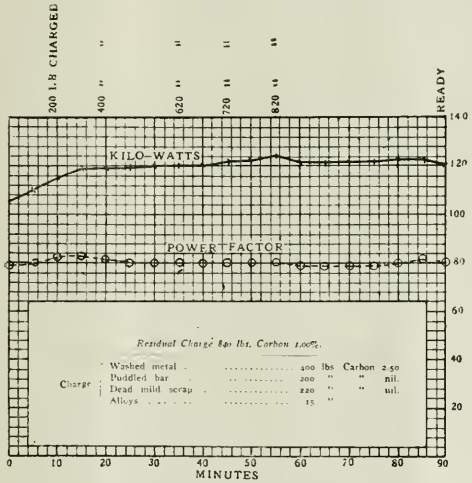


Fig. 2—Power Consumption and Power Factor; Charge 800 Lbs.

poured just under 1½ hours, the power consumption being only 440 kw. hours per ton. This result is exceptionally good, but, with suitable arrangements for handling the product, there is no reason why carbon tool steel should not be regularly produced with a consumption of under 600 kw. hours per ton.

Fig. 2 illustrates the power consumption and power factor on a charge of over 800 pounds:

Before leaving the subject of crucible quality steel, it might be well to call attention to the consideration this particular type of furnace is receiving in Sheffield.

The first firm to take up the matter was Vickers' Sons & Maxim, Ltd., who erected a furnace of 250 kw. capacity, which after preliminary trials, commenced active operations in the spring of 1908.

About this time a committee of manufacturers was formed to go very thoroughly into the quality and costs of production of high-grade steel by electricity. A technical sub-committee visited electric furnace plants, the Kjellin furnace at Gysinge, Sweden, attracting a lot of attention. They were very well satisfied with the material produced, and, as a direct resut of their exhaustive tests and report, a furnace of 300 pounds' capacity has recently been put in operation in the metallurgical department of the Sheffield University.

Another of the large firms, always in the forefront on improvements, is William Jessop & Sons. They hope to immediately commence operations on a furnace capable of producing 8 to 10 tons per day. In fact, this may already have started. It was only after long consideration and investigation as to the best furnace for their purpose that their decision fell on the Kjellin furnace. They had already tried out one of another design.

It will be perfectly apparent that this class of melting is making headway in the most conservative of all steel centers, Sheffield.

Leaving the subject of steel melting for a short time, the melting of other metals will be touched upon.

NICKEL MELTING.

Experiments were carried out at Niagara Falls, working with a 60-kw. furnace. The furnace lining was of magnesite, thoroughly baked in, and heated to redness by means of an iron ring. This ring was removed, molten nickel poured in, the current switched on and heating of charge commenced. The molten nickel charge was 108 pounds, and the charging of cold nickel commenced at 2:15 p. m. The following are the readings taken:

Time.	Volts.	Amperes.	K. V. A.	Remarks.
2.15	135	300	40.5	Started to charge scrap, 50 lbs.
2.25.	144	350	50.3	
2.30	140	360	50.4	
2.35	135	365	49.2	
2.40	133	370	49.2	Charging finished.
2.50	133	370	49.2	
3.00	130	376	49.5	Shut down to change connections.
3.06	120	350	42.0	Started.
3.15	120	350	42.0	
3.30	120	350	42.0	
3.45	120	350	42.0	
3.56	120	350	42.0	Teemed 43 lbs. and took sample No. 1.
4.00	125	300	37.5	Started.
4.12	146	350	51.1	Started charging 50 lbs. electrolytic nickel.
4.15	137	388	50.4	
4.18	124	375	46.5	Charging finished.
4.22	123	370	45.5	Complete melt.
4.24	106	325	34.5	
4.30	115	350	40.2	
4.35	115	350	40.2	Teemed 50 lbs. Sample No. 2.
4.37	128	330	42.2	
4.41	128	330	42.2	Started charging 50 lbs. electrolytic nickel.
4.45	132	337	44.4	
4.48	129	340	43.8	
4.51	130	350	45.5	
4.54	126	357	45.0	
4.57	125	360	45.0	
5.00	124	361	44.8	
5.03	122	362	44.2	
5.05	121	366	44.3	Charging finished.
5.06	122	368	44.8	Complete melt.
5.10	120	368	44.1	
5.20	94	342	30.2	

The metal was kept in a molten state, and the following morning at 11 o'clock sample No. 3 was taken. Nothing further was done until two mornings afterwards, the metal meanwhile being maintained in a molten condition. This delay was caused by the absence of a New York gentleman who desired to witness the work, who was unavoidably detained, and the metal

was kept melted awaiting his arrival. On the morning of the fourth day work was resumed, the following readings being taken:

Time.	Volts.	Amperes	K. V. A	Remarks.
7:00 A. M	106	235	21.9	
7:30	112	250	28.0	
8:00	112	250	28.0	
8:20	112	250	28.0	
9:30	125	265	33.6	
10:05	127	265	33.6	
1:00 P. M	126	255	32.1	
1:20	130	262	34.1	
1:30	150	300	45.0	
1:45	150	300	45.0	Sample No. 4.
1:47	150	300	45.0	Started charging 31 lbs electrolytic nickel.
1:50	148	307		
2:00	126	321		
2:10	126	300	37.8	
2:35	126	300	37.8	
2:40	148	350	61.8	
2:55	146	348		Charged 3 lbs. manganese.
3:00	146	348		Teemed. Sample No. 5.

The samples taken showed:

	1st sample.	2d sample.	3d sample.	4th sample.	5th sample.
Metallic iron	0.56%	1.45%	0.35%	0.39%	0.53%
Nickel oxide	nil.	nil.	1.25%	15.95%	11.40%

Sample No. 1 shows a great deal of iron, which possibly occurred from iron scale falling from the baking-in ring. The iron decreased rapidly on charging further quantities of nickel, and from other causes.

It is not surprising that a great quantity of nickel oxidized, being kept molten for such a long period, and it is satisfactory to note the reduction of the amount of oxide on adding manganese.

Another point which would affect the nickel was that the men who had to watch the furnace over night were quite unfamiliar with the work, and maintained too high a temperature, as they were afraid of the bath freezing.

It will be seen that the melting was very rapid for the first charge, although the furnace was not very hot, and, including delays, took only 1½ hours, and in the second we commenced charging 50 pounds at 4.12, obtaining a complete melt at 4.22 and teemed at 4.35.

This work was experimental and consequently we were not working under the best conditions. The furnace was giving a power factor of about 90 per cent, therefore it will be seen that with an average kw. of 48.4, the power consumption for this quantity was at the rate of 325 kw. hours per ton for melting only, which is very good for so small a furnace.

There are certain difficulties in melting the first charge, and, to overcome them, the first lot was melted in crucibles and poured into furnace. I will refer again to this difficulty in my next paragraph.

BRASS MELTING.

Very little work has been carried out in this country on brass and bronze, and, on that account, the information obtained is from England. The Grondal-Kjellin Company, Limited, 20 Abchurch Lane, London, E. C., worked on brass, and, when the ordinary furnace was used, were troubled with the "pinch effect," so well known to you all, through the constant reference to it by Mr. Carl Hering, who has made a study of the phenomenon. They overcame the difficulty by using a special crucible, together with specially constructed coil on the furnace, whereby the electrical conditions could be so changed that at any desired moment most of the current could be carried either by the metal in the bath or by the crucible itself. By this arrangement the crucible is first heated, and, when sufficiently hot, the brass scrap is charged. This soon melts, completing a circuit. The switch is then thrown over, and the metal itself carries most of the current; the crucible, when exposed, gradually becomes cooler, the cooling being visible.

After the first melt was obtained, 112 pounds of brass were charged and melted in about 30 minutes, with a power supply of about 30 kw., and twice the quantity only required 50 kw., melting in the same time. The first heating of the crucible required 42 kw. hours, and took 1½ hours.

The brass produced was remarkably sound, and, when tested against that produced in the ordinary way, showed excellent results.

In addition to this work, other experiments have been carried out on a 3-phase furnace, the lining being of firebrick. The result of these experiments shows a power consumption of 18 kw. hours per 100 kgs., or about 185 kw. hours per gross ton.

The "pinch" effect is far less intense in the use of 3-phase current as compared with single-phase.

As this work is still being carried out, it is not possible to give final results at the present moment.

There are now several small simple induction furnaces at work in this country, and abroad they are in regular commercial use.

There have been several very able papers which have been read on this subject, one of which was by Dr. Kjellin last year. These go well into costs and give so many details that these particulars have been purposely avoided, and, as previously stated, so much repetition is unnecessary, for all interested will, as a matter of course, look up previous papers.

THE COMBINATION INDUCTION FURNACE.

This is known as the Rochling & Rodenhauser furnace, and is used for melting and refining. The Rochling'sche Eisen & Stahlwerke, Volklingen, with their characteristic enterprise, were early in the field, and erected an 8-ton Kjellin furnace. They wished to obtain, for special purposes, a higher grade of steel than they were producing in the basic Bessemer converter, and attempted refining in the Kjellin furnace. Owing to the construction of this, they were unable to freely handle slags, and although able to refine, it was with great difficulty. The eventful result was that the furnace bearing their name was evolved from the Kjellin furnace, and the capacity has increased until now they are working a furnace which takes the full output of their generator.

It is interesting to note that it was their intention to refine ordinary steel to obtain steel of somewhat

beter quality, and they did not intend commencing the tool steel business, but now, as they have had so many requests and orders for large quantities of the high-grade quality, they have rapidly built up a large business, and are erecting a new plant at a great cost to take care of this.

It very soon became quite evident that the combination furnace had entered the field as a refiner, and is now in the first rank, acomplishing work which skeptics regarded as impossible.

You will find, on referring to pages 173-204 of Vol. XV., 1909 Transactions of this Society, a general description and costs of operation, etc., all of which can easily be followed by the help of the accompanying figures.

The refining is also well shown, and the writer can not add much new matter to that paper.

However, a few particulars of observation personally made at the Volklingen Works may be of interest to you.

At the time of the writer's arrival, the 2-ton 3-phase furnace was in operation. Two casts of nickel-chrome steel were made. The following day the charges were for the production of high-grade silicon steel. These were produced from metal obtained from the basic Bessemer converter. Figures on these runs were not taken.

Wishing to get further particulars, samples of a heat were taken in order to follow up the refining, and at the same time electrical readings were also taken. These are shown in Table I.

TABLE I—REFINING OF STEEL IN 2-TON 3-PHASE ROCHLING-RODENHAUSER FURNACE.

Time	—Amperes—			Volts.		Kw.	Power factor.	Remarks.
2:20								Charging molten metal.
2:30	128	128	130	310	320	45	0.70	
2:45	470	480	482	440	450	235	0.65	
3:00	490	495	505	485	495	275	0.65	
3:15	500	510	518	470	480	260	0.62	
3:30	495	510	510	460	465	250	0.61	
3:45	495	500	505	470	480	250	0.60	
4:00	485	495	506	470	480	272	0.67	
4:15	400	405	410	470	480	230	0.69	
4:30	373	377	390	490	500	205	0.63	
4:45	380	385	390	500	510	250	0.74	
5:00	505	508	518	475	485	263	0.63	
5:15	500	506	512	470	475	250	0.60	
5:18								Pouring out.

FURNACE OPERATIONS.

Weight of furnace and charge.....21,105 kilos
Weight of furnace .....19,610 kilos

Weight of molten steel ..... 1,495 kilos

Time.
2:25 Charging furnace.
2:27 Samples taken. Steel sample No. 1. Slag sample No. 1.
2:40 20 kilos lime and 6 kilos roll scale thrown on bath.
2:27 Sample taken. Steel sample No. 2.
3:00 4.5 kilos iron ore briquette added.
3:10 Bath stirred (to work in slag).
3:15 Samples taken. Steel No. 3. Slag No. 2.
3:17 30 kilos lime, 7 kilos roll scale, 4.5 kilos briquettes added.
3:20 Stirred.
3:22 7 kilos scale charged. Bath stirred.
3:30 55 kilos lime added.
3:35 Sample taken. Steel sample No. 4.
3:40 Rabbled well to work in very stiff slag.
3:55 Sample taken. Steel No. 5.
3:58 Removing slag (3 mins.). Slag sample No. 3 taken.
4:03 4 kilos slaked lime thrown in to gather up a small amount of remaining slag. Removed at 4:10.
4:13 Steel sample No. 6.
4:14 3 kilos Fe-Si added.
4:15 7 kilos retort carbon added.
4:16 Reduced current.
4:19 40 kilos desulphurizing slag mixture added.
4:23 5 kilos fluorspar added to thin down the slag.
4:35 Rabbled. Slag fluid. Steel sample No. 7. Slag sample No. 4.
4:37 7 kilos slag mix, and 6 kilos Fe-Si added.
4:42 Rabbling. Weight of furnace and contents at this stage 21,050 kilos.
4:53 3 kilos Fe-Mn added. Steel sample No. 8. Slag sample No. 5 taken 5:57.
5:05 to 5:10 temperature tests.
5:18 Pouring. 1.5 kilos Fe-Si added to ladle.
Steel sample No. 9 and slag sample No. 6 from ladle.
Weight of furnace, 19,645 kilos. Metal poured, 1,405 kilos.

TABLE II—ANALYSIS.

Slag Samples.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Silica	16.11	11.28	6.51	20.72	19.40	26.72
Alumina	1.57	0.98	0.59	2.68	4.42	5.54
Ferrous oxide	12.43	17.51	16.78	1.05	1.12	0.93
Ferric oxide	10.73	12.59	9.71	....	....	....
Mangan. oxide	16.89	11.90	5.52	0.18	0.50	0.74
Lime	34.57	37.93	55.01	63.60	63.53	55.40
Magnesia	4.13	3.44	3.84	3.47	3.88	5.21
Phos. pentoxide	3.16	3.39	1.24	0.055	0.078	0.023
Calcium suphide	0.17	0.92	0.86	3.94	2.72	2.23
Loss on ignition.	....	....	....	4.28	4.38	3.28
	100.06	99.94	100.06	99.97	100.02	100.07
Iron	17.33	22.43	19.84	0.82	0.87	0.72
Manganese	13.09	9.22	4.28	0.13	0.39	0.57
Phosphorus	1.38	1.48	0.55	0.024	0.034	0.010
Sulphur	0.21	0.41	0.38	1.73	1.21	0.99

Steel Samples.

	Carbon	Silicon	Sulphur	Phosphorus	Manganese
No. 1	0.08	0.005	0.069	0.070	0.41
No. 2	0.05	0.007	0.070	0.039	0.29
No. 3	0.04	0.011	0.075	0.014	0.19
No. 4	0.03	0.055	0.074	0.012	0.14
No. 5	0.03	0.002	0.060	0.007	0.10
No. 6	0.03	0.003	0.061	0.005	0.11
No. 7	0.56	0.013	0.033	0.012	0.16
No. 8	0.62	0.159	0.013	0.019	0.51
No. 9	0.60	0.165	0.011	0.021	0.51

The above particulars show that the refining took 2 hours and 58 minutes, and used up 653 kw. hours.

The amount of refining materials used was:

Lime—109 kgs. at $1.50 per 1,000 kgs..... 0.16
Roll scale—29 kgs. at $4.00 per 1,000 kgs... 0.116
Carbon—7 kgs. at $5.00 per 1,000 kgs..... 0.035
Flourspar—5 kgs. at $5.00 per 1,000 kgs.... 0.025
Slag mixture—47 kgs. at $2.50 per 1,000 kgs. 0.117
Ferro silicon—10.5 kgs. at $62.00 per ton... 0.651
Ferro manganese—3.0 kgs. at $45.00 per ton 0.135

1.239=96c per ton

The total weight of steel tapped was about 1,500 kgs.

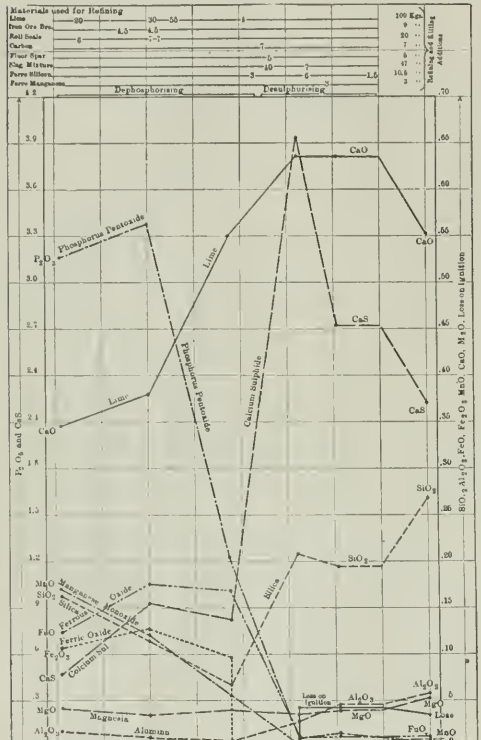
The above may seem costly, but at the Volklingen Works all the slag goes to the blast furnaces, so there is really very little loss, and consequently liberal use of these materials was made. Most of the lime was used to stiffen the slags in order to facilitate raking off. And, again, the steel was produced in a small furnace, which is always more extravagant than a larg one. Had this furnace been working at its rated capacity, the refining material used would have been very slightly increased, when the cost of refining material would have been decreased to about 75 cents per ton.

COSTS.

Power, 653 kw. hours per charge = 435 kw. hours per ton, at 0.5c per kw. hour.....$2.175
Refining materials, $1.44 per charge, per ton..... .96

Labor, 3 men at say $3.00 per day, $9.00 production per ton equals 4 charges at 17½ tons, each = 6 tons.....	1.50
Lining costs, $52.00 for material and $20.00 for labor $72.00; life, 12 days at 12 tons = 144 tons.....	.50
Repairs, say	.10
	$5.235

These costs look enormous, but, as before stated, the smallness of the furnace has to be taken into consideration, and here we have an estimate based on actual working for producing tool steel from molten basic Bessemer iron at a cost of only $5.25 per ton of ingots above the price of basic Bessemer ingots.



Refining of Basic Bessemer Metal in a 2-Ton, 3-Phase R. & R. Furnace at Volklingen—Slag Sample.

This ought to appeal to tool steel manufacturers, especially as all grades of steel are produced, for the writer witnessed the production of all tempers of carbon steel, high speed, high silicon, nickel chrome, tungsten and other steels in this furnace, which had just been erected and was new to the men, so that better results may be expected at a later date.

EIGHT-TON FURNACE.

This was witnesed in active operation. Here again all grades of steel were being produced, but, as the demand for alloy steels is not so great as that for carbon steels, the latter were predominant.

Again, molten metal was generally used for the charge, and, as the production of high-grade steel was taking place with monotonous regularity, there was really nothing to excite one's enthusiasm. Just as soon as they broke away from molten metal for the whole charge, and used part metal and part scrap, readings were taken and particulars followed up. These are given in the following tables:

Time	Volts	Amperes	Kw.	Power Factor	Remarks	
12.15	1,000	138	440	0.79	Charged molten metal.	
12.30	4,300	138	500	0.84		
12.45	4,300	138	500	0.84		
1.00	4,300	138	500	0.84		
1.15	4,200	140	500	0.85		
1.30	4,100	148	500	0.77		
1.45	4,620	156	600	0.85		
2.00	4,550	157	597	0.84		
2.15	4,500	160	595	0.83		
2.30	4,490	157	570	0.82		
2.45	4,500	160	580	0.81		
3.00	4,500	160	580	0.81		
3.15	4,500	160	580	0.81		
3.30	4,100	150	500	0.81		
3.45	3,900	141	455	0.83		
4.00	3,650	131	395	0.81		
4.15	3,570	123	355	0.81		
4.30	3,180	115	295	0.81		
4.45	3,180	115	295	0.81		
4.53	3,870	143	450	0.81		
5.00	3,870	143	450	0.81		
5.05	3,650	135	400	0.81		
5.15	3,650	135	400	0.81	Casting.	

12.15	Charged molten Bessemer metal.....	1st sample
12.50	Charged portion cold scrap.	
1.50	Charged final portion cold scrap.	
2.30	All melted	2d sample
2.50	95 kilos lump lime and 50 kilos roll scale added.	
3.00	Slag fluid	3d sample
3.10	160 kilos lime added to stiffen slag.	
3.30	Removing slag. 45 kilos lime added to stiffen remaining slag.	
4.00	Removing slag.	
4.10	Charged 28 kilos carbon and 12 kilos Fe Si	
4.15	.....	4th sample
4.20	100 kilos desulphurizing slag mixture charged	
4.25	10 kilos flourspar charged.	
4.27	Stirred bath.	
4.32	.....	5th sample
4.35	25 kilos Fe-Si thrown over slag.	
4.38	Rabbled slag (brown color).	
4.42	4 kilos Fe-Si and 4 kilos slag added.	
4.45	Charged 45 kilos Fe-Mn.	
4.50	Rabbled slag.	
4.55	Rabbled slag.	
5.00	.....	6th sample
5.15	Tapped.	
	15 kilos Fe-Si added to ladle when casting	7th sample

APPROXIMATE AMOUNT OF STEEL, 6 TONS.

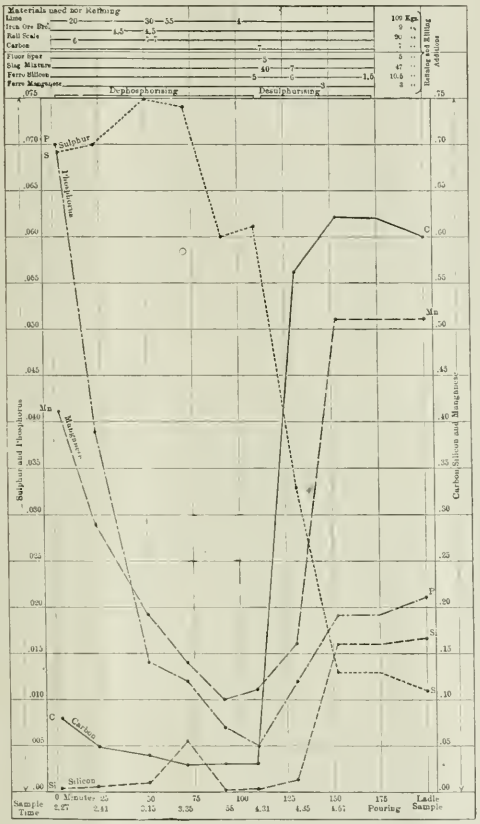
Fluxes, etc., used.	Kilos per charge	Kilos per ton			
Lime used (255 + 45).....	300	50	at $1.00	per ton	$0.05
Roll scale used.....	50	8⅓	" 2.50	" "	0.021
Ferro-silicon (12+25+4+15)	56	9⅓	" 66.00	" "	0.616
Ferro-manganese	15	7½	" 45.00	" "	0.30
Desulphurizing slag mixture.	104	17⅓	" 5.00	" "	0.10
Fluorspar	10	1⅔	" 5.00	" "	0.009
Carbon	28	4⅔	" 5.00	" "	0.023
					$1.12

The steel was desired low in carbon, phosporous and sulphur, and, on that account, extra refining materials were used.

Slag samples of this charge were not taken, as they are at best a matter of curiosity and cannot give any definite information, as most of the lime is used for mopping purposes only.

On referring to the time table and purification curve, it will be seen that the phosphorus was at its lowest just as soon as the cold metal was melted. The process of dephosphorizing was carried on for another

1½ hours, thereby consuming 800 kw. hours, together with a large quantity of lime and roll scale. The extra cost of these materials amounted to 6½ cents per ton, and the labor would be equivalent to about 20 cents per ton, and power 66½ cents per ton, the total amounting to about 93 cents per ton. The lining would also have produced extra tonnage. This waste would



Refining of Basic Bessemer Metal in a 2-Ton, 3-Phase R. & R. Furnace at Volklingen—Steel Samples.

not be allowed in this country, but, on considering that high-grade steel is produced, for which a very high price is obtained, the extra cost per pound amounts to 0.04 cent, which is very litle.

This must not be regarded as the usual practice, but was due to a lack of care on the part of the workmen.

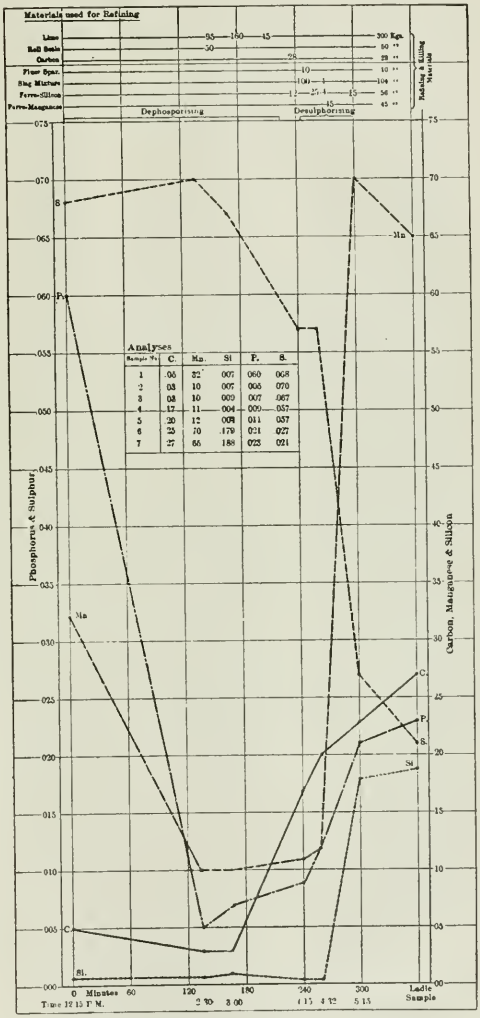
Not only did the extra oxidizing cost the 6½ cents for the lime and oxide, but, on calculating it out, it was found that the 28 pounds of ferro-silicon was required to take care of it, which is equivalent to 30 cents per ton, and the costs as previously given are really higher than they ought to be.

The total amount of power consumed was 2,400 kw. hours, equivalent to 400 kw. hours per ton, using part cold metal.

The costs, then, on this material are as follows:

Refining materials	$1.12
Power, 400 kw. hours, at 5c.	2.00
Labor, 3 men $9.00, at 14⅔ tons per turn	.62
Lining	.30
	$4.04

But it has been shown that as much as $1.23 were



Refining of Basic Bessemer Metal in an 8-Ton, Single Phase R. & R. Furnace at Volklingen.

wasted on power, labor, etc., to which must be added another 7 cents' waste on lining, making a total of $1.30 to be deducted; therefore the costs should be:

As observed	$4.04
Less waste	1.30
Cost should be	$2.74

In any case the figures given for a high-class steel are very good.

As has been pointed out very frequently, for the re-

fining of molten basic Bessemer steel for electric steel rail quality the costs are very low, and attention is again directed to Dr. Kjellin's paper where, on pages 105 and 107, he goes into costs very thoroughly.

SIXTEEN-TON REFINING FURNACE.

The estimated costs of operation of a 16-ton furnace working on basic Bessemer steel, and refining to 0.03 to 0.035 per cent S. and P., and 0.50 to 0.80 per cent C., are in accordance with the following:

SUMMARY.

	Per Ton.
Materials charged	$15.50
POWER.	
Heating, refining and cooling	0.535
WAGES.	
On furnace	0.115
On lining	0.011
Lining materials	0.054
Repairs	0.190
	$16.005

License, tools, amortization and interest omitted.

MATERIALS USED.

2,240 lbs.	basic Bessemer metal	$14.00
12 "	burnt lime, $1.50	0.028
14 "	ferro-silicon, at $62.00 per ton	0.387
22 "	ferro-manganese, at $45.00 per ton	0.442
2 "	fluorspar, at $5.00 per ton	0.004
22 "	roll scale, at $4.00 per ton	0.004
11 "	crushed carbon, at $5.00 per ton	0.025
2,276 "	of metallic material	$14.890
68 "	loss 3 per cent.	
2,208 "	yield, costing	14.89
2,240 "	will therefore cost	15.10

POWER CONSUMPTION.

For Drying and Baking.
6,500 kw. hours, at 0.5c per kw. hour, $32.50,
say 2,100 tons per lining ..... $0.015 per ton
For Refining.
100 kw. hours per ton, at 0.5c ..... 0.50 " "
For Cooling Fan.
10 kw. for driving fan at 0.5c per unit ..... 0.02 " "
Total for power ..... $0.535 " "

WAGES PER 24 HOURS.

2 melters at $6.00 each $12.00
10 laborers, cranemen, boys, etc., at $2.00 ..... 20.00
$32.00
Daily production, say 280 tons.
Wages, per ton 0.115
Lining.
2 foremen, at $5.00 ..... $10.00
8 laborers, at $2.00 ..... 16.00
Total per lining, 2,400 tons $26.00
Therefore labor on lining per ton 0.011
Lining Materials.
Based on figures from Volklingen records, where dolomite mixture costs $7.00 per ton, as against $6.50 per ton here $0.054

These figures are based on continuous working and little or no loss of time between heats. One hour and twenty minutes is allowed from tap to tap.

There is no reason why this should not be done as a regular thing, for when working on rail steel in Volklingen on the 8-ton furnace this time was frequently reduced. What "held them up" chiefly was the fact that as they were dependent on the Bessemer plant, they could only obtain metal when it did not interfere with the operation of the mills, and on that account they were often waiting for metal.

The figures given in Table III are from a run of 42 consecutive heats on the 8-ton furnace.

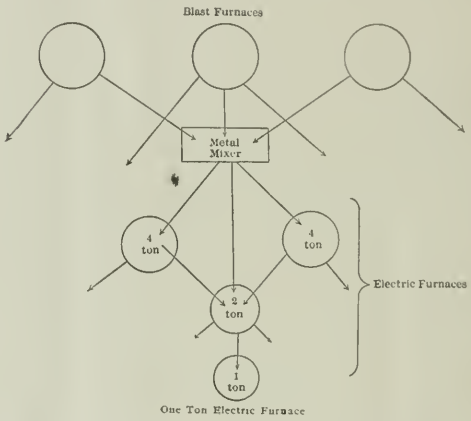
STEEL FROM PIG IRON.

So far the use of molten pig iron as the raw material from which to produce high-grade steel in the Rochling & Rodenhauser furnace has not been dealt with, but think it would be of interest to the Society if a few particulars were given of the work now being carried on by the Le Gallais Metz et Cie, Dommeldingen.

This firm commenced operations on a very small (1-ton) Rochling & Rodenhauser furnace. They were so satisfied with the results that they erected another of twice the capacity (2 tons). So encouraging were the results that they have recently erected two more furnaces of four tons each capacity, and have built quite a large electric steel casting plant.

The method they used was to take molten pig iron direct from the blast furnace, and, by numerous additions, eliminate the impurities until the desired composition was attained.

The new plant, which is just completed, is arranged as follows:



One Ton Electric Furnace

These furnaces are so arranged that they may be worked singly or in series.

The gas fired mixer is of 25 tons capacity, and was erected by Wellman, Seaver & Head, of London, England. In this mixer the Luxembourg pig iron is poured and treated by the addition of ores, lime and scrap, and is worked as an open-hearth furnace.

The pig charged is of the following analysis:

Carbon	1.0%
Manganese	1.3
Silicon	1
Phosphorus	1.8
Sulphur	.15

and the finished mixer metal as charged into the electric furnaces in 3½ to 4-ton lots contains:

Carbon	.10 - .30%
Phosphorus	.05 - .07
Sulphur	.05 - .07

After treatment in the eletric furnace, the steel, which is used exclusively for castings, runs:

Carbon	.07 - .10%
Manganese	.20 - .35
Silicon	.15 - .15
Phosphorus	.008 - .01
Sulphur	.008 - .01

The actual composition varies with requirements.

This refining is accomplished with two slags only.

As will be seen, the method is really a development of the electric furnace with which the casting business was commenced, and this firm have made provision for further development by allowing room for additional furnaces as the demand increases.

MELTING OF FERRO MANGANESE AND MANGANESE STEEL SCRAP.

Experiments were carried out at Niagara Falls to demonstrate the suitability of the induction furnace principle for melting this class of material. As these

TABLE III.

Basic Steel P.	Basic Steel S.	Electro Steel C.	Mn.	Si.	P.	S.	Remarks.
0.049	0.061	1.01	0.33	0.15	0.020	0.022	For heating 4,994 kw. hrs.
0.059	0.065	1.04	0.33	0.18	0.012	0.024	
0.050	0.067	0.79	0.33	0.26	0.012	0.029	
0.060	0.069	0.16	0.33	0.015	Trc.	0.032	It was afterwards found that the lime was running high in sulphur, which would account for the erratic results.
0.054	0.067	0.64	0.89	0.16	0.020	0.016	
0.072	0.079	0.96	0.33	0.084	Trc.	0.014	
0.067	0.067	0.51	0.83	0.15	0.026	0.018	
0.048	0.059	1.20	0.33	0.12	0.015	0.020	
0.055	0.087	0.92	1.06	1.12	0.018	0.020	
0.059	0.079	0.23	0.47	0.019	0.012	0.055	
0.053	0.071	0.57	0.87	0.24	0.018	0.029	
.052	.063	1.02	0.39	.18	.016	.018	
0.050	0.067	0.82	0.34	0.096	0.024	.016	

Basic Steel P.	Basic Steel S.	Electro Steel C.	Mn.	Si.	P.	S.	Remarks.
.058	.061	0.80	0.37	.054	.021	.020	Most of the high sulphur steels are low in carbon.
.059	.065	0.93	0.40	0.16	.020	.018	
.043	.089	0.92	0.34	.070	.013	.024	
.070	.075	0.18	0.40	.024	Trc.	.038	
.072	.069	0.86	0.40	0.16	.023	.019	
.058	.081	0.62	0.96	0.16	.024	.020	
.060	.067	0.07	0.37	.028	Trc.	.059	
.056	.097	0.66	0.82	.066	.023	.032	
.089	.091	0.08	0.44	.024	.021	.030	
.076	.055	1.00	0.84	0.14	.010	.018	
.053	.123	0.10	0.40	.030	Trc.	.038	
.065	.079	0.93	0.87	0.11	.024	.020	
0.062	.071	1.01	0.84	0.19	.020	.024	
.078	.073	0.82	0.81	0.11	.025	.027	
.061	.067	0.88	0.31	0.25	.016	.032	
.051	.077	0.59	0.78	0.22	.019	.029	
.050	.059	1.06	0.75	0.20	.015	.024	
.035	.057	1.10	0.86	0.20	.013	.020	
.060	.063	1.10	0.34	.047	.015	.022	
.065	.079	0.98	0.34	0.23	.012	.014	
.071	.048	1.02	0.34	0.22	.013	.018	
.052	.077	0.83	0.87	0.20	.019	.020	
.064	.061	0.92	0.84	0.16	.020	.014	
.063	.063	0.83	0.79	0.13	.014	.012	
.060	.055	0.92	0.37	0.17	.010	.020	
0.68	.075	1.00	0.23	0.16	Trc.	.024	
.072	.079	1.08	0.28	0.22	Trc.	.016	
.053	.065	0.88	0.76	0.13	.012	.020	
.075	.071	0.30	0.76	0.22	.014	.029	

tests were of a private nature, the information obtained cannot well be made public. On this work the furnace proved an unqualified success, melting the materials with great rapidity, very slight loss of manganese content, and low power consumption.

A furnace has been erected in Germany to melt ferro manganese for a basic Bessemer plant.

The writer can only trust that this paper will be of some slight interest, for it only skims the surface, and it has not been intended to carry out any argumentative assertions, controversial points having been carefully avoided, but, before closing, the attention of all is directed to the very steady load which is so desirable in all electric furnaces and compensates for the apparent low power factor.

ÉFFICIENCY IN THE ELECTROLYTIC PRODUCTION OF METALLIC CALCIUM.*

By FRANCIS C. FRARY, HENRY R. BICKNELL AND CARL A. TRONSON.

Most of those who have worked on the electrolytic production of calcium have been content to describe their methods and apparatus, with perhaps an analysis of a selected lump of their product, but say nothing of the current efficiency obtained. Muthmann,[1] in the discussion of a paper by Rathenau, states that by using an electrolyte consisting of two parts of calcium chloride to one part of the fluoride, and raising the iron cathode as the metal accumulated, he obtained a "good" yield. Goodwin,[2] electrolyzing pure calcium chloride in a similar way, obtained a current efficiency of 21.5 per cent to 41.9 per cent. Woehler,[3] using an electrolyte containing 100 parts of the chloride to 17 parts of the fluoride, claims an efficiency of over 80 per cent, but states that the electrolyte deteriorated in time, probably owing to the formation of the hydrated oxychloride, and that hydrogen (!) is then liberated at the cathode, and the yield decreases. He used a current of 40 amperes at 33 to 38 volts, but does not say how often or for how long a time this efficiency could be obtained. Tucker and Whitney[4] improved the apparatus of Goodwin, and claim an efficiency of 60 per cent, using the pure chloride as electrolyte, but give no data to support the claim. As far as we are able to ascertain, no one else has published any results on the efficiency of the various processes which have been proposed.

During previous work in this laboratory,[5] efficiencies as high as 46 per cent were obtained, but, unfortunately, the only runs in which the necessary data were taken were made under unfavorable conditions. As it was certain that better results could be obtained and had been obtained in some of the runs for which no data were at hand, these were not published at the time, and the work was continued by the present authors.

The apparatus used was the same as that described by Frary and Badger,[5] and consisted essentially of a large crucible of Acheson graphite having a water-cooled bottom and serving as anode, and a water-cooled iron cathode a little over an inch in diameter. The crucible was enclosed in a protective layer of refractory material, and especial pains were taken with the contact between it and the positive cable. The cathode could be raised or lowered at will by means of a screw mechanism.

From preliminary experiments, it was decided that

*Paper presented at the 18th General Meeting of the American Electrochemical Society, in Chicago, Oct. 13-15, 1910. The work described in this paper is a continuation of that published by Frary and Badger (Trans. Am. Electrochem. Soc., 1909, 16, 185), where a summary and discussion of previous work on the electrolytic production of calcium will be found.

[1] Z. Elektrochem., 10, 508 (1904).
[2] J. Am. Chem. Soc., 27, 1403 (1905).
[3] Z. Elektrochem., 11, 612 (1905).
[4] J. Am. Chem. Soc., 28, 84 (1906).
[5] Frary and Badger, loc. cit.

the occasional feeding of the fresh electrolyte and irregular raising of the cathode were two important causes of low efficiency. Intermittent addition of electrolyte caused irregularities in the height of the melt and its temperature, especially the latter. Too great cooling of the electrolyte caused the deposition of the metal in a spongy form, in which state it was readily lost. Spongy portions were also formed when the stick of metal extended too far below the surface of the melt, the current density[6] being insufficient to melt the metal at the point of contact with the electrolyte, and thus produce a solid stick. This spongy metal was very likely to be dislodged and swept away by the vigorous convection currents which were always present; it also gave trouble by growing toward one side or other of the crucible, causing an increase of current at that point, with consequent increased growth of metal and a higher temperature, until finally the calcium on the edges would melt, and, being connected with the main stick only by thin pieces of metal, would be easily swept away by the electrolyte. When the end of the stick of metal was kept just below the surface of the electrolyte, the spongy metal at first formed melted almost at once, and its surface tension drew it into a compact globule which was almost immediately frozen by the cooling effect of the rest of the stick and the water-cooled cathode. Thus a solid stick was easily obtained. To get the best results, it was found necessary for one person to devote all his attention to the raising of the cathode and the addition of the electrolyte, making both operations practically continuous.

The chloride used was some of Merck's C. P. granulated, which had previously been used in dessicators. It was dried in an iron crucible over a four-post Bunsen burner, and preserved in a stoppered bottle.

In starting up a run, the cold fused chloride remaining in the crucible from a previous run was heated until dry by directing the flame of a blast-lamp upon it. Then a small portion of it was fused by drawing an arc from the side of the crucible with the aid of a graphite rod. A small current was used until contact was made with the cathode, when more current was put on and the graphite rod removed. As soon as good contact was assured, the direct current was shut off, and an alternating e. m. f. of about 30 volts applied. The current usually rose rapidly to about 200 amperes, being regulated by raising or lowering the cathode, and the upper part of the crucible was soon filled with molten chloride. A sufficient supply of electrolyte was added at this time to fill up the crucible, and when all was ready, the alternating current was thrown off and the direct current thrown on. Readings of the time, voltage and amperage were taken at once. The voltmeter and ammeter were read every five minutes during the run, and the average of these readings considered to be the average voltage and amperage for the run. The current varied very little during each run, as it was taken from the 110-volt lighting circuit through a constant resistance. There was no trouble with the so-called "anode effect," except when the electrolysis was started before a sufficient amount of the electrolyte had been melted down by the alternating current.[7]

The formation of the metal under the cathode was watched very carefully, great care being necessary to get a good start. We aimed to withdraw the cathode and metal as rapidly as it was possible to do so without striking an arc. It will be noticed in the table of results that practice in doing this increased the yield obtained. When the electrolysis is going on properly, and the stick of metal is at the right depth, the electrolyte seems to flow rather rapidly across the surface in a fixed direction, and is hottest at the cathode. The operator must be guided by the appearance of the electrolyte at the cathode. There should be a rosette-like spot with radial markings here; if the stick of metal is pulled out too fast, this spot becomes almost white hot, and if the metal is not at once lowered, an arc forms, and part of the metal is melted off and lost. If the stick it not raised fast enough, the spot becomes less noticeable, and spongy metal deposits below the surface, causing losses. When the electrolysis was well under way, new electrolyte was added in small portions, taking care to make these additions as continuous as possible, and in such a spot that the convection currents carried the cold chloride away from the metal. Table I shows the efficiency obtained.

TABLE I.

Run No.	Time. Min.	Amperes.	Volts	Weight. Gm.	Efficiency, Per Cent
1	60	74.45	18.3	30.8	55.3
2	60	73.9	21.4	25.	45.2
3	60	74.2	21.	43.5	78.4
4	38	73.2	26.	27	77.8
5	32	73.1	24.4	26.5	90.7
6	30	71.5	25.5	24	89.8
7	27	70.4	33.	21.5	90.5
8	30	69.66	28.	26.	100.
9	34	52.51	34.	21.6	97.
10	36	68.75	31.	31.	100.5

The sticks of metal were cleaned by hammering off the crust on the outside, and then placing them in absolute alcohol for 24 hours to remove the rest of the chloride. When taken out of the alcohol, the sticks were always clean, though covered by a thin coat of oxide. They were dried by burning off the alcohol, and weighed. The current was, of course, not absolutely constant, so there is a possible error of one or two per cent in the efficiency as calculated, but the results are sufficiently accurate for practical purposes.

Since Ruff and Plato,[8] Muthmann,[9] and Wochler[10] have recommended the use of a mixture of the chlo-

[6] In most cases a rod of about 1 cm. diameter was obtained, so the cathode area was about 1 to 1½ sq. cm.

[7] A sample of the electrolyte was taken at such a time, when the "anode effect" had been more than usually troublesome, and the per cent of silica present determined. Only 0.056 per cent was found, confirming the results obtained in the previous paper, and indicating that current density rather than impurities should be blamed for this "effect."

[8] Ber. 35, 3612 (1902); 36, 491 (1903); D. R. P. 153, 731 (Chem. Centr. 1904, II, 802).

[9] Z. Elektrochem., 10, 508 (1904).

[10] Z. Elektrochem., 11, 612 (1905).

ride and fluoride as the electrolyte, we decided to try it and see if it offered any advantages. The fluorspar was first partially purified by treatment with concentrated hydrochloric acid to remove iron. It was mixed with the chloride in the proportion of 16.5 parts to 100, as recommended by Ruff and Plato. A new crucible was made for use with this electrolyte, having the same size as the other, but a different arrangement of the water-cooling. The bottom of the crucible was turned out on the lathe so as to fit loosely over the hollow brass cooling cylinder of the Borchers[11] furnace for the electrolysis of fused salts. The crucible was then turned upside down, this space filled with a strong copper sulphate solution, and copper deposited until the cylinder would not enter the space. The copper was now turned out on the lathe to fit the cylinder, and the whole of the outside of the crucible and cylinder protected from the air by a coat of Portland cement and carborundum fire-sand, held in place, as before, by a tin form. The contact being made through the water-cooling cylinder, was kept cool and did not burn away, as the other crucible did in the course of time. A more complete protection of the outside of the crucible was also possible.

With this crucible and the above-mentioned electrolyte a new series of runs was made. Considerable trouble was found in making smooth, solid sticks of metal with this electrolyte. The particular advantage of this mixture is supposed to be its low melting point (660°). This appears to us to be a disadvantage, as the bath must be worked at a temperature of nearly 750° in order to get a solid stick of metal, and the bath is so fluid at the working temperature that convection currents are more violent and more likely to sweep away the metal from the end of the stick, forming an arc. We had a great deal of trouble from this cause. Reduction of the current did not bring the desired result, as the efficiency decreased markedly (Run No. 6, Table II). The results obtained are shown in Table II.

TABLE II.

Run No.	Time, Min.	Amperes.	Volts.	Weight. Gm.	Efficiency, Per Cent.
1	30	42.	..	15.	95.5
2	32.5	41.5	31.	15.	89.2
3	42	53.9	37.	27.	95.7
4	35	45.6	31.3	12.8	64.4
5	9	54.9	26.	5.	81.2
6	41	31.9	30.	5.	30.6
7	45	52.1	29.5	18.	61.6
8	45	53.5	30.7	26.	86.6
9	46	69.3	31.4	29.4	74.
10	40	52.7	34.	22.6	86.
11	35	53.5	30.8	20.	85.5

During the runs with this electrolyte, only the chloride was added, it being assumed that the fluoride would not be decomposed. However, at the close of these experiments a sample from the top of the melt showed only 2.21 per cent of insoluble matter, so, evidently, much of the fluoride had been lost. This loss was probably largely mechanical and due to the violent spattering of the electrolyte; it was noticed that a great deal more of the fine dust from the electrolyte collected on the crucible and its surroundings with this than with the simple chloride electrolyte.

We also took samples from the electrolyte in the lower part of the crucible, which had been kept frozen during the electrolysis by the cooling coil, and so, presumably, retained its original composition, and attempted to isolate the fluochloride of calcium described by Poulenc[12] and Defacqs,[13] but found none of it.

From our experience with both electrolytes we believe that the plain chloride is a little more satisfactory than the mixture of the chloride and fluoride in point of efficiency, and decidedly easier to manipulate. We have shown that satisfactorily high efficiencies can be obtained with it, and that efficiency is more largely a matter of careful regulation of conditions than anything else.

[11]Borchers. "Die Elektrische Oefen." 1907 ed., pp. 35 and 36.

There has been a notably large increase in sheet mill capacity in the past few years. No new sheet plants were built this year, but existing companies have built additional sheet mills as follows: Inland Steel Co., Indiana Harbor, Ind., 8; Massillon Rolling Mill Co., Massillon, O., 4; National Sheet Steel Co., Mansfield, O., 1; Stark Rolling Mill Co., Canton, O., 1; Thomas Steel Co., Niles, O., 5; West Penn Co., Brackenridge, Pa., 3; Youngstown Sheet Tube Co., Youngstown, O., 8. The total number of sheet mills (including jobbing mills) in existence is 424, of which 240 are controlled by independent interests and 184 by the Steel Corporation. With the 27 mills being built by independents the independent total promises to be 267, while with the 20 sheet and jobbing mills being built at Gary the Steel Corporation total promises to be 204. In the total of 240 independent sheet mills are included 12 mills which have not operated for some time, 229 having been in operation at one time or another recently. In the Steel Corporation's total of 184 are included 17 mills, which have not operated since June, 1909.

The U. S. Civil Service Commission, Washington, D. C., has postponed until Jan. 4, 1911, the examination scheduled for Oct. 19, 1910, to secure eligibles from which to make certifications to fill two vacancies in the position of chemical engineer in forest products in the Forest Products Laboratory at Madison, Wis., at salaries ranging from $1,600 to $2,500 per annum, and vacancies requiring similar qualifications. The examinations to secure eligibles from which to make certifications to fill four vacancies in the position of chemist in forest products in the Forest Products Laboratory at Madison, Wis., at salaries ranging from $1,600 to $2,500 per annum, were also postponed until Jan. 4, 1911.

[12]Ann. Chim. Phys., [7], 2, 5 (1894).
[13]Ann. Chim. Phys., [8], 1, 337 (1904); Compt. rend., 137, 1251 (1903); J. Chem. Soc., 86, ii, 123 (1904).

THE LABORATORY

METHODS OF ANALYSIS FOR ENAMEL.*

By ROBERT D. LANDRUM.†

The fact that practically nothing has been published on the above subject, and the remembrance of the many long hours spent in digging out these methods and adapting them to enamels and enamel raw materials, has led the author to put them in this form for others who might use them. While he claims little originality in the methods themselves, he does claim originality in the adaptations here given. Each and every one of these methods has been thoroughly tried out, either in the laboratory of the Columbian Enameling & Stamping Co., at Terre Haute, Ind., or in the chemical laboratories of the University of Kansas.

The analysis of an enamel presents one of the most difficult and complicated problems with which the analyst comes in contact. An enamel is generally an insoluble silicate containing besides silica, iron, alumina, calcium, magnesium and the alkalies, generally boron, fluorine, manganese, cobalt, antimony and tin, and sometimes phosphorus and lead. Before attempting the quantitative analysis of any enamel a thorough qualitative analysis should be run, and this will enable one to choose a quantitative separation. One of the most important aids to a correct analysis is a thorough grinding. The sample should be ground to an almost impalpable powder, and every conceivable precaution for accuracy taken.

The analysis of a sample of enamel to be taken from a piece of ware involves an extra difficulty. The coating of enamel almost always consists of two or more layers—the lower a large ground coat, and the upper ones white or colored enamels. For an illuminating analysis these must be separated. The author has found the following method of V. de Luyeres[1] good for doing this: The surface is scratched lightly with a piece of emery cloth or a file, and a coating of gum acacia or glue is applied. The vessel is placed in an air-bath and heated. The glue on hardening generally carries with it some of the outer coat. The glue or gum is then broken off, dissolved in water and the enamel pieces collected on a filter paper. Some obstinate enamels require painstaking methods, such as chipping off with a chisel and separating the different coats—which always vary somewhat in color—by picking out and sorting, using a pair of forceps. A large reading glass will be useful in making these separations. Any iron from the vessel which may adhere to the enamel may be removed by means of a magnet after the sample is ground.

ANALYSIS OF AN ENAMEL CONTAINING FLUORINE.

In an enamel containing fluorine the usual methods for silicates cannot be used, as silicon-tetra-fluoride would be volatilized in the evaporation with hydrochloric acid for the separation of the silica.

Fluorine.—One gram sample is very finely ground, slowly fused with two grams each of potassium carbonate and sodium carbonate. The melt should be kept in quiet fusion over as low a flame as possible for one hour. The melt is transferred (after cooling quickly by giving the crucible a gyratory motion while held in the tongs, causing the melt to cling to the sides instead of forming a solid cake in the bottom) to a platinum dish where it is covered with a watch glass and boiled vigorously with one hundred cc. of water. The residue is filtered off and is saved for the determination of the metallic oxides and the silica.

The covered solution is digested on a steam bath for an hour with several grams of ammonium carbonate, and on cooling more carbonate is added and the solution is allowed to stand for twelve hours. The precipitate of silica, alumina, etc., is filtered off, washed with ammonium carbonate water and is saved for further determinations.

The solution containing all the fluorine and traces of silica, phosphate, etc., is evaporated until gummy, then diluted with water and neutralized as follows: Phenolphthalein is added, and nitric acid (double normal) drop by drop until solution is colorless.

The solution is boiled and the red color which reappears is again discharged with nitric acid, boiled again and neutralized again until one cc. of acid will discharge the color.

The last traces of silica, etc., are now removed, as recommended by F. Seemann (Zeit. Anal. Chem. 44, p. 343), by the addition of 20 cc. of Schaffgotsch solution. This solution is made as follows: 250 grams of ammonium carbonate are dissolved in 180 cc. of ammonia (0.92 sp. gr.) and the solution is made up to one liter. To the cold solution 20 grams of freshly precipitated mercuric oxide are added and the solution is vigorously shaken until the mercuric oxide is dissolved.

The precipitate caused by the Schaffgotsch solution is filtered off and saved, and the solution is evaporated to dryness and the residue taken up with water.

Any phosphorus from the bone ash used in some enamels, and chromium which may be present, are

*From a paper read at the Pittsburg meeting of the American Ceramic Society, February, 1910.
†Lawrence, Kans.
[1]Compte Rendus 8, p. 480.

removed from this alkaline solution by adding silver nitrate in excess. Phosphate, chromate and carbonate of silver are here thrown down and may be determined if desired.

The excess of silver is removed from the solution by sodium chloride, and one cc. double normal sodium carbonate solution is added to the filtrate, and the fluorine is precipitated by boiling with a large excess of calcium-chloride solution.

The precipitate, consisting of a mixture of calcium carbonate and fluoride, is collected on a blue ribbon filter paper and is washed, dried, ignited at low red heat, separated from the filter paper, and the residue with the ash of the paper is treated with dilute acetic acid until carbon dioxide is no longer given off on heating. The liquid is then evaporated to dryness, the residue taken up with hot water (slightly acidified with acetic acid) filtered, dried and gently ignited and weighed as CaF_2. This may be checked by heating with sulphuric acid, driving off all the excess of acid and reweighing as $CaSO_4$. This method gives results for the amount of fluorine checking within 0.2 per cent, but which are generally from 2 per cent to 4 per cent low.

Silica.—For the estimation of silica and the metallic oxides, first the precipitate from the Schaffgotsch mercuric oxide solution is ignited to drive off the mercuric oxide, and the silica left is weighed. The residue from the original melt, together with the precipitate obtained by ammonium carbonate (after the drying and removal from the filter paper whose ash is added) are then dissolved in hydrochloric acid. The solution is evaporated to dryness and moistened with hydrochloric acid. It is diluted with water and the silica is filtered off, weighed, and this with that previously obtained is the total silica.

Iron, Alumina and Manganese.—The solution from the silica is raised to boiling and the iron and aluminum are precipitated as hydroxides. Then 5 cc. of bromine water is added and the boiling continued for five minutes. The precipitate is dried on filter paper and ignited separately from it in a weighed platinum crucible, to which the ash of the filter-paper is afterwards added. The precipitate consists of Al_2O_3, Fe_2O_3, and Mn_2O_3, and is weighed as such. It is then fused with fifteen times its weight of potassium pyrosulfate over a low flame for three hours with the crucible covered. The crucible, contents and cover are placed in a beaker and dilute sulphuric acid (10:1) is added. By warming and continued shaking of liquid complete solution may be obtained. It is then drawn through a Jones reductor to change all the iron to ferrous and titrated with N/10 potassium permanganate solution. The iron is calculated to Fe_2O_3 and the alumina determined by difference.

If manganese is present it is determined in a separate sample in a method given later and is subtracted from the iron in the above. In white enamels containing only a trace of iron the manganese may be determined in the solution from the pyrosulfate fusion. A freshly prepared solution of potassium ferricyanide is added to oxidize the manganese, then the solution is made alkaline with sodium hydroxide solution and the manganese-dioxide thus formed is filtered off. The solution is then made acid and the ferrocyanide is titrated with N/10 potassium permanganate solution. (1 cc. $KMnO_4 = 0.00435$ gram MnO.)

Calcium Oxide.—The filtrate from the iron and alumina is raised to boiling, treated with boiling ammonium oxalate solution and digested on water bath until precipitate readily and quickly settles after being stirred. The calcium oxalate is now filtered off and ignited wet in platinum to constant weight over a strong blast.

Magnesium Oxide.—The solution is evaporated to dryness and the residue ignited to remove ammonium salts. The residue is treated with a few drops of hydrochloric acid and taken up with boiling water and filtered from the carbonaceous residue. To the boiling solution is added drop by drop a solution of sodium ammonium phosphate and is allowed to cool. Half as much concentrated ammonium hydroxide is added as there is solution and it is allowed to stand over night. The precipitate is collected on a filter, washed with 3 per cent ammonia water, dried in oven and ignited separate from the filter. The heat is applied gently at first and finally with the highest heat of a good Bunsen burner. It is then weighed as $Mg_2P_2O_7$.

1 gram $Mg_2P_2O_7 = .3625$ grams MgO.

The alkalies are determined by the method of J. Lawrence Smith from a gram sample finely powdered. This method is standard and need not be given here.

SEPARATION AND DETERMINATION OF ANTIMONY, TIN, MANGANESE AND COBALT IN ENAMEL.

Decomposition.—Two grams finely powdered sample are transferred to a platinum dish, and after moistening with a little water, pure hydrofluoric acid is added and the whole is mixed with a platinum spatula. The dish is digested on steam bath for five hours covered with platinum cover (a larger platinum dish may be used for cover if no other is at hand). After the decomposition is complete the solution is evaporated to dryness on steam bath. The residue is moistened with enough dilute sulphuric acid (1:1) to make a thin paste, and evaporated as far as possible on a steam bath and then on a hot plate, all the time being covered to prevent spirting. As soon as fumes of sulphuric anhydride cease to be evolved the cover is strongly heated until fumes cease to be driven off, when it is removed. The contents are heated by bringing the dish to dull redness directly over a Bunsen burner. The sulphates thus formed are moistened with strong hydrochloric acid, a little hot water is added and the solution boiled with repeated additions of acid and water until completely in solution. In some enamels—especially those with high melting points—the stannic oxide remains undissolved, and a

fusion of the residue with sulphur and sodium carbonate may be necessary.

Treatment with H_2S.—The solution containing at least 30 cc. double normal hydrochloric acid is transferred to a 500 cc. Ehrlenmeyer flask fitted with a double bored stopper. Through one of the holes a right-angled piece of glass tubing is introduced that just reaches to the lower edge of the stopper, while through another hole another right-angled glass tube is fixed so that it almost reaches the bottom of the flask.

A Kipp H_2S generator is connected to the longer tube and H_2S is passed through for half an hour and the solution is let stand for another half an hour; after which the suphides of antimony and tin are transferred to a filter paper and the solution is kept for the determination of manganese and cobalt.

Antimony and Tin.—The precipitated sulphides are dissolved in a solution of potassium polysulphide—if any lead or copper is present it will remain undissolved and may be determined separately—by pouring this successively through the filter into a 300 cc. Jena beaker, and finally washing with water containing a small amount of potassium polysulphide.

Antimony.—The antimony and tin in this solution are separated by F. W. Clark's method as modified by F. Henz[2], as follows:

To the solution in the Jena beaker 6 grams caustic potash and 3 grams tartaric acid are added. To this mixture twice as much 30 per cent hydrogen peroxide is added as is necessary to completely decolorize the solution, and the latter is now heated to boiling and kept there until the evolution of oxygen is over, in order to oxidize the thiosulphate formed. All of the excess of peroxide cannot be removed successfully at this point. The solution is cooled somewhat, the beaker covered with a watch-glass, and a hot solution of 15 grams pure recrystallized oxalic acid is cautiously added (5 gms. for 0.1 gm. of the mixed metals). This causes the evolution of considerable carbon dioxide. Now, in order to completely remove the excess of hydrogen peroxide the solution is boiled vigorously for ten minutes. The volume of the liquid should amount to from 80 to 100 cc. After this a rapid stream of hydrogen sulphide is conducted into the boiling solution, and for some time there will be no precipitation, but only a white turbidity formed. At the end of five or ten minutes the solution becomes orange colored and the antimony begins to precipitate, and from this point the time is taken. At the end of fifteen minutes the solution is diluted with hot water to a volume of 250 cc., at the end of another fifteen minutes the flame is removed, and ten minutes later the current of hydrogen sulphide is stopped. The precipitated antimony pentasulphide is filtered off through a Gooch crucible which, before weighing and after drying, has been heated in a stream of carbon dioxide at 300° C. for at least one hour. The precipitate is washed twice by decantation with 1 per cent oxalic acid and twice with very dilute acetic acid before bringing it in the crucible. Both of these wash liquids should be boiling hot and saturated with hydrogen sulphide.

The crucible is heated in a current of carbon dioxide (free from air) to constant weight, and its contents weighed as Sb_2S_3.

The filtrate is evaporated to a volume of about 225 cc., transferred to a weighed unpolished platinum dish, and electrolyzed at 60° to 80° C. with a current of 0.2 to 0.3 ampere (corresponding to 2 to 3 volts). For very small amounts of tin, a current of not over 0.2 ampere should be used. At the end of six hours 8 cc. of sulphuric acid (1:1) are added, and at the end of twenty-four hours the solution is transferred to another dish. The deposited tin has a beautiful appearance, similar to silver.

Tin.—The plated tin is washed thoroughly with water and the dish is dried in an air oven at 110° and weighed.

The solution containing the cobalt and manganese is boiled until free from H_2S. The iron is oxidized back to the ferric state by the addition of bromine water and boiling until the excess of the latter is expelled. Ten cc. double normal ammonium chloride is added and the iron and alumina are precipitated by the addition of ammonia and are filtered off. (The iron alumina may be determined from this precipitate if desired.)

The solution still containing the manganese and cobalt is transferred to an Ehrlenmeyer flask fitted for passing in H_2S, as before described, and 3 cc. strong ammonia is added. H_2S is passed through for some time, and after precipitation ceases 3 cc. more of ammonia are added and the flask is filled to the neck (300 cc. flask), is corked and set aside for twelve hours at least. The precipitate is collected and washed on a small filter with water containing ammonium chloride and sulphide.

Manganese.—The manganese is extracted from the precipitate on the filter by pouring through it strong H_2S water acidified with 1/5 its volume hydrochloric acid (sp. gr. 1.11). This solution from the extraction is evaporated to dryness, ammonium salts are destroyed by evaporation with a few drops of sodium carbonate solution, hydrochloric acid and a drop of sulphurous acid are added to decompose excess of carbonate and to dissolve the precipitated manganese, and the latter is reprecipitated at boiling heat by sodium carbonate after evaporating off the hydrochloric acid. The manganese is weighed as Mn_3O_4 and calculated to MnO_2, in which form it is probably present in the enamel.

The residue of cobalt sulphide left after extracting the manganese is burned in a porcelain crucible, dissolved in aqua regia, and evaporated with hydrochloric acid; the platinum—and copper if any is present—are thrown down by heating and passing in

[2]Treadwell, Vol. II, p. 188.

hydrogen sulphide. The filtrate from the platinum and copper is made ammoniacal, and cobalt is thrown down by hydrogen sulphide. This is filtered off and washed with water containing ammonium sulphide. This is either ignited and weighed as oxide or more accurately determined by dissolving in an ammoniacal solution of ammonium sulphate, containing 10 grams of ammonium sulphate and 40 cc. of concentrated ammonia for each 0.3 grams of cobalt, and electrolyzing in a weighed platinum dish at room temperature with a current of 0.5 to 1.5 ampere, and an electromotive force of 2.8 to 3.3 volts. The electrolysis is finished in three hours. The circuit is broken and the liquid poured off, and the platinum dish is washed with water, then with absolute alcohol (distilled one hour) and finally with ether, allowed to dry in oven at 95° for one minute and then weighed. The metallic cobalt is calculated as CoO, in which form it is present in the enamel.

THE DETERMINATION OF BORIC ANHYDRIDE IN ENAMEL.

The boron is determined in a separate sample of about 0.3 grams. This finely pulverized sample is fused with three grams sodium carbonate for fifteen minutes, is taken up with 30 cc. dilute hydrochloric acid and a few drops of nitric acid. The melt is heated in a 250 cc. round bottomed flask almost to boiling, and dry precipitated calcium carbonate is added in moderate excess. The solution is boiled in the flask after it has been connected with a six-inch worm reflux condenser. The precipitate is filtered on an 8 cm. Buchner[3] funnel, and is washed several times with hot water, taking care that the total volume of the liquid does not exceed 100 cc.

The filtrate is returned to the flask, a pinch of calcium carbonate is added and the solution is heated to boiling to remove the free carbon dioxide. This is best done by connecting the flask to a suction pump, and the suction is applied during boiling. The solution is cooled to ordinary temperature, filtered if the precipitate has a red color, and four or five drops of phenolphthalein is added and N/10 sodium hydroxide solution is run in slowly until liquid has a strongly pink color. A gram of mannite (or 150 cc. of neutral glycerol) is added, whereupon the pink color will disappear. Continue to run in N/10 sodium hydroxide until end point is reached. Add more mannite or glycerol and if necessary more alkali, until a permanent pink color is obtained.

1 cc. N/10 Sodium Hydroxide = .0035 g. B_2O_3.

Lead.—The enamel for cooking utensils should never contain lead. To determine whether a cooking utensil contains lead, E. Adam gives the following simple qualitative method: A small piece of filter paper moistened with hydrofluoric acid is placed upon the enamel and allowed to remain for some minutes; the paper, together with any pasty mass adhering to the enamel, is then washed off into a small platinum basin, diluted with water, and tested for lead by passing H_2S through the solution.

J. Grünwald (Oesterr. Chem. Ztg. 8, p. 46) gives another quick test for lead: Wet small portion of surface with HNO_3 (conc.) and heat until acid is evaporated. Add several drops of water and a few drops 10 per cent potassium iodide solution, and if even a trace of lead is present yellow lead-iodide will be produced.

DETERMINATION OF PHOSPHORIC ANHYDRIDE IN ENAMEL.

Enamels containing bone ash to give opaqueness are analyzed for P_2O_5 as follows:

To a gram sample of very finely pulverized enamel in a platinum crucible one cc. of sulphuric acid is added and the crucible is filled half full (about 10 cc. are required) with hydrofluoric acid. The crucible is heated on the water bath until most of the solution is evaporated and then gently on a hot plate to remove all the fluorine as silicon-tetra-fluoride and as hydrofluoric acid, but no sulphuric acid fumes should evolve, as P_2O_5 is volatile. The residue is dissolved in nitric acid and taken to dryness, moistened with nitric acid, diluted with water, filtered and washed with a very little water.

Add aqueous ammonia to the solution from above until the precipitate of calcium phosphate first produced just fails to redissolve, and then dissolve this by adding a few drops of nitric acid. Warm the solution to about 70° C. and add 50 cc. ammonium molybdate solution (70 g. MoO_3 per liter). Allow the mixture to digest at 50° for twelve hours. Filter off precipitate washing by decantation with a solution of ammonium nitrate made acid with nitric acid.

The precipitate on the filter is dissolved by pouring through it dilute ammonia solution (one volume of 0.96 sp. gr. ammonia to three volumes of water).

The solution is received in the beaker containing the bulk of the precipitate, all of which is dissolved in the ammonia solution.

An excess of magnesium ammonium chloride ("magnesia mixture") solution is added very slowly and with constant stirring. Let solution stand over night. Decant clear solution through a filter and wash by decantation with ammonia water (1:3). Dissolve the precipitate by pouring a little hydrochloric acid (sp. gr. 1.12) through the filter, allowing the acid solution to run into the beaker containing most of the precipitate. When all the precipitate on the filter and in the beaker is dissolved wash the filter paper with a little hot water. To the solution add 2 cc. magnesia mixture and then strong ammonia, drop by drop, with constant stirring until distinctly ammoniacal. Stir several minutes, then add strong ammonia equal to one-third of the liquid, let stand two hours and filter off the precipitate of magnesium ammonium phosphate. Wash with dilute ammonia water, dry the precipitate, ignite separately from the filter, first at low temperature and gradually raise to full blast. Weigh precipitate as $Mg_2P_2O_7$ and calculate as P_2O_5 in sample.

[3]See Method of Wherry and Chapin, Jr., Am. Chem. Soc. 30, p. 1688, for Determination of Boron in Silicates.

METALLURGY.

EFFICIENCIES OF COMBUSTION PROCESS COMPARED.

By THEO. J. VOLLKOMMER.

(Concluded from September Issue.)

COMBUSTION WITH 100 PER CENT EXCESS AIR.

The plain grate furnace always requires a very great excess of air, and analyses of the stack gases show that on the average about double the theoretically required quantity is admitted. This great excess is necessitated by the irregularities in the layer of coal, where frequently thin spots of the coal bed allow streaks of air to pass through the grate without mixing well with the carboniferous gases from the thicker parts of the bed. The heat developed by a pound of coal is the same as in the previous cases—13,755 B. t. u—but this amount of heat has to act on a large volume of combustion gases, as the excess of air amounts to about 123 cu. ft. (at 0 degrees). This much diluted gas volume will become heated to only about 1,320 degrees C. if it absorbs all the heat developed by the combustion of the fuel. As it was stipulated that the combustion gases should leave the hearth (or space around the muffle) at about 1,200 degrees C., only the difference of about 120 degrees would be available for heating the charge (muffle) and for radiation. This difference at these temperatures would mean a difference in energy of 12,500 B. t. u., so that not more than 1,255 B. t. u. out of the total heat liberated could be absorbed by the charge and brick work. If the latter is assumed, the radiation through the brick work of the hearth, at 500 B. t. u., which is rather too low than too high, only 755 B. t. u., or nearly one-eighteenth, only is utilized or absorbed by the charge (or muffle), while seventeen-eighteenths of the total heat generated is lost for practical purposes.

This remarkably low efficiency would rise if it is not necessary to heat the charge to above 1,000 degrees C. To melt a metal or metal mixture melting at 500 degrees C. so that the gases could leave the hearth at, say, 600 degrees C., only 5,909 B. t. u. would be carried off. Allowing the same amount for radiation as in the previous case (500 B. t. u.) of the 13,755 B. t. u. liberated by the combustion, 7,346 B. t. u. could be absorbed by the charge, or nearly 50 per cent of the liberated heat. This example serves to show that for low hearth temperatures plain grate combustion can be fairly economical, and expensive devices for preheating the combustion air would be out of place. On the other hand, the higher the temperature of the hearth the less economical the grate fired furnace becomes. The difficulty of keeping the grates uniformly covered has led to the adoption of gas fired furnaces.

ADVANTAGES OF GAS.

The writer has frequently met those having the erroneous impression that by first converting the fuel into gas more heat could be obtained per pound of fuel. In fact, just the opposite is the case, and the heat carried off by radiation and other causes in the producer is irretrievably lost, and this loss is generally between 10 and 15 per cent. The advantage of producer gas is, therefore, not caused by the liberation of more heat, but by the reduction of the quantity of combustion gases to be heated by the liberated heat. It has been found possible to mix the gas and air so well that an excess of only 5 to 15 per cent of air is required to obtain nearly perfect combustion. Thus a well constructed and well operated gas furnace can come within 15 to 20 per cent of the efficiency of the combustion in the first illustration, where no excess of air was allowed.

The loss of heat and consequently the reduction of the maximum temperature is the more pronounced the cooler the gas enters the furnace. For one or only a few furnaces it is, therefore, preferable to attach the producer to the furnace, so as not to lose heat by radiation in the flues. By this arrangement one also avoids the trouble of deposition of soot in the flues, which, especially in hot working producers, necessitates frequent cleaning out (burning out) of the flues. For numerous furnaces the inconvenience of hauling the fuel and cinders to and from the different furnaces proves generally a greater nuisance, or evil, than the loss of heat by radiation in the flues, and a central producer plant with flues leading to the different furnaces is preferable. Here also may be considered the question of whether producers should be blown with air alone or with steam injection.

Without going far into theoretical consideration, it can be said that where the gasification takes place near the furnace, air blast will be better than steam injection. Steam is no fuel and, therefore, cannot develop heat and the admitted or injected steam, which has a very great capacity for absorbing heat, will leave the hearth at a certain temperature (in the comparative case at 1,200 degrees) with all the heat it carries at that temperature.

If enough steam is admitted so that one-quarter of the oxygen required in the producer for grasification is supplied by the oxygen contained in the steam (as is frequently the case) the waste gases will contain about 11.8 cu. ft. (at 0 degrees C.) of steam per pound of coal, which will carry off (at 1,200 degrees C.)

about 826 B. t. u. which would be saved in the case of air blast. On the other hand, when the steam is decomposed its constituents may be cooled down to the lowest temperature, but they will always carry with them this latent heat until it is again liberated by combustion and converted into sensible heat. The decomposed steam, or, rather, its constituents, being almost unsurpassed carriers of latent heat, are used to advantage where the producer gas is cooled very much before reaching the combustion chamber.

If the gases derived from the gasification of 1 lb. of coal were cooled down to 0 degree C. before reaching the furnace, the amount of heat liberated in the final combustion would be in the case of one-quarter mixed gas about 3,370 B. t. u. larger than in the case of air blast (or Siemens gas). This assumes a case which probably will never occur in practice, but all cases in practice lie between these two extremes, and by making allowance for the proportions of moisture or steam to the injected air, one will be able to at least approximate the real conditions.

Aside from the above consideration another fact renders the use of steam blast in producers commendable, if not to the furnaceman, at least to the producer attendant.

The presence of steam in the blast air renders the cinders far more friable and loose, making it less difficult to break up the clinkers, which with dry air blast cause considerable muscular exertion. The furnace man, however, must make up his mind to the fact that the presence of steam in the combustion gases has, according to tests lately made in Germany, a somewhat injurious effect on the brick work, which evil effect is more noticeable the oftener the temperatures change.

AIR AND GAS PREHEATING.

It has been shown that the higher the temperature of the hearth, or the working temperature, the lower the efficiency of the furnace. Therefore where high temperatures are needed, if they can be obtained at all in grate fired furnaces, their utilization is so limited as to make the process too costly. In this case a remedy is furnished by the preheating of either the combustion air alone or of preheating both the air and fuel gas The preheating of the air in grate furnaces is not feasible, as it would tend to speedily destroy the grate bars, which even with cool air are subject to frequent repairs. The preheating of air is, therefore, applied only to oil fired and to gas fired furnaces. The least expensive source of heat by which to preheat the air (and gas if the latter is also preheated) are the waste gases, or the combustion gases, leaving the hearth at high temperature (in the comparative investigation only at 1,200 degree C.) There are two methods in practical use to thus utilize the heat of the waste gases, the regenerative and the recuperative.

REGENERATIVE METHOD.

The first, invented by W. Siemens, consists in the use of two (or four) chambers filled with loosely piled brick or checker work, through one (or two) of which the waste gases are converted on their way to the stack. After this checker work has been thoroughly heated the current of the gases is reversed by a set of valves. Then the combustion air (and fuel gas) is conducted through the hot checker work and thus preheated on the way to the combustion chamber, while the waste gases return through the other chamber or chambers. Every time the heat of the checker work becomes exhausted by imparting the heat to the air (and gas) the valves have to be reversed again.

The advantage of this arrangement is the high temperatures to which the air (and fuel gas) can be heated and the ease of renewing the checker work after it has become defective. The disadvantages are the changes in temperatures (very high after each reversal and low after the heat in the checker brick has been partially absorbed by the air and the gases); the necessity of frequent reversals of the valves, especially when the furnaces get thoroughly hot, which reversals require considerable attention on the part of the men, if they are to be properly timed, and also cause considerable loss of fuel gas, as the volume of gas in the chamber at the time of the reversal is allowed to escape unburned to the stack, and the space which the checker chambers and the reversing valves and flues occupy. With all these objections, the regenerator is the best and safest furnace for very high temperatures.

RECUPERATIVE METHODS.

Lately another method of preheating the air has been greatly improved, which, especially for small and medium size furnaces with high temperatures, is likely to replace regenerators to a considerable extent. This is called recuperation and consists of conducting the hot waste gases through a system of tubes of refractory material around which the combustion air is compelled to take its way before reaching the combustion chamber. No reversing of air and gas takes place, both flowing uninterruptedly in the same direction, whereby the costly valve mechanism and the trouble of operating it is saved. No fuel gas is lost by the reversing, far less room is required and the cost is somewhat less than that of a regenerator system. The temperature, owing to the abolition of reversing, is far more uniform. The objection which was frequently raised against this type of furnace, that the recuperative tubes or channels were difficult of access and difficult to repair, has been to a great extent remedied, as in modern constructions the tubes can be inspected, cleaned and ever minor leaks repaired without stoppink the operation of the furnace.

On the other hand, the recuperator tiles are more likely to break than checker brick, and one broken tube necessitates removing and relaying a number of other tubes. Notwithstanding the greater uniformity of temperature (compared with regeneration) a certain expansion and contraction of the tubes is unavoidable and will result in a certain amount of leakage.

Considering, however, that the waste gases contain about 21 per cent more heat units than the air required for final (secondary) combustion could possibly absorb even if heated to the same temperature, which is not possible, a moderate amount of leakage from the air spaces around the tubes to the inside and to the stack will not affect the efficiency considerably. The fact remains that, especially in Germany, recuperative furnaces find very great favor, and are built in large numbers to the advantage of their owners if applied in the proper place.

The thermal calculations for either of these modifications are equivalent. By either method, if 1 lb. of coal is gasified and burned, the same number of heat units is obtained as in the direct coal fired furnaces, (less the loss in the producer.) If the secondary or combustion air is heated to 1,000 degrees C. it brings further 2,828 B.t.u. into the furnace, bringing the total heat available up to 24,495 B.t.u. The gases leaving the hearth (as above stipulated) at 1,200 degrees carry off only 6,000 B.t.u. The difference, 8,495 B.t.u., is available for heating the charge and for radiation. If this latter is assumed to be 1,600 B.t.u., out of the 13,755 B.t.u. contained in 1 lb. of coal, about 7,895 B.t.u. could be absorbed by the charge or about 43 per cent.

The 6,000 B.t.u. carried away from the hearth by the combustion gases are not allowed to go to the stack, but are used to preheat the air.

It takes 2,828 B.t.u. to heat the required quantity of secondary air to 1,000 degrees, and if about 2,000 B. t.u. is allowed for loss by radiation from the recuperator, the combustion gases would leave the recuperator with 2,172 B.t.u., or with a corresponding temperature of about 400 degrees C. Recuperative furnaces are in operation in which the combustion air is preheated to a temperature only 20 to 25 degrees lower than the temperature of the gases leaving the hearth. The combustion is so nearly perfect that 19 per cent of carbonic acid is found in the stack gases, while 21 per cent would be the highest possible percentage in the combustion of average Pittsburgh coal.

CONCLUSIONS.

Coal grate furnaces are fairly economical for low temperatures, especially if a large volume of gases is desired. The large excess of air in this case renders the flame oxidizing, which is generally desired in muffle furnaces for enameling and ceramic furnaces. On metal articles this flame would produce a heavy scale, or oxidation, and in metallurgical furnaces (especially a deep fuel bed for iron and steel) producing a reducing flame with little or no air excess, and consequently with high temperature is preferable. With working temperatures above 1,000 degrees C. and for continuous operation the installation of recuperative or regenerative furnaces will prove a good investment.

While the foregoing data may assist the furnaceman in comparing the merits of the different processes of combustion, the nature of the products, the cost of fuel, labor and maintenance, and the construction of the furnace and its first cost, and other local conditions, make it necessary to study each case individually, to consider every factor having an effect upon the efficiency, usefulness and durability of the furnace and, after selecting the proper type, to modify the construction to suit the special requirements.

REDUCTION OF TIN DROSS IN AN ELECTRIC FURNACE.*

By R. S. WILE.†

Electrical heat was resorted to for the smelting of tin dross because of the fact that the heat could be internally applied to the slag, which is on the bottom of a shaft-type of furnace, thus enabling the dross to be thrown on top of the slag instead of being mixed with it as is done in the old style of furnace. The dross, being on top, comes in contact with the slag only at the point of reduction. The liberated gases filter through the dross, while any tin oxide which is volatilized is condensed in the colder portion of the dross, which, as I have said, is on top of the slag. The globules of tin produced in smelting pass downward through the slag and loose most of the impurities, so very little refining of the resultant product is necessary.

In operation, the top carbon, which is movable, is brought into contact with the lower carbon, which is stationary, and an arc formed. The slag is fed in and melted, and the carbon is raised until the desired amount of slag is added. The dross, mixed with the right percentage of carbon, is added, and the tin tapped from the bottom from time to time. The loss of tin has been kept as low as 0.25 per cent, and the average below 1 per cent. The amount of tin recovered varies largely on account of the varying percentages in the drosses treated. The average is about 2,500 lbs. (1,100 kg.) per day.

The plant consists of two furnaces, connected in series, both being 20 ins. (50 cm.) in diameter and 80 ins. (200 cm.) high inside, two 50 kw. transformers and necessary electrical apparatus. In operation they consume about 44 kw. During the run it is desired to keep the amperage as near constant as possible, the voltage varying. At the start the voltage of each furnace is about 80, but toward the end, as the slag becomes less refractory, due to the combination of the iron and zinc of the dross and the slag, the voltage of each furnace will drop as low as 45-50. This and an analysis of the slag denotes the end of the operation, and the slag must be drawn out and new put in. This is done alternately with each furnace. The furnaces run continuously until time to be relined, which is about every three or four months.

*Paper presented at the 18th General Meeting of the American Electrochemical Society, in Chicago, Oct. 13-15, 1910.

†Riverside Metal Refining Co., Connellsville, Pa.

THE USE OF ELECTRICITY FOR STEEL REFINING.*

By D. F. CAMPBELL.

The use of electricity for the refining of steel has now taken its place amongst established metallurgical processes, and many papers have been written on the subject of electric furnaces, but the author proposes to discuss briefly the general aspects of the subject, and what he considers the probable and possible developments in the immediate future in England. The electric furnace is at present used in various works for the refining of steel from the Bessemer converter in the manufacture of rails and all classes of railroad material and castings, and more commonly in connection with the basic open-hearth process for the manufacture of various products of intermediate quality, castings and tool steel of all kinds. These are the purposes for which it has been most widely adopted, notably in America, Germany and France, though it is also used for melting and refining charges of cold scrap of cheap quality for the manufacture of tool steel and small castings, and its high efficiency is now generally acknowledged. The refining of steel that had been previously melted was the first use to which the electric furnace was applied commercially; but now that single furnaces have been producing over 200 tons a day for more than 16 months, it is obvious that the field for the process has widened, and already many furnaces are in construction or operation in this country.

The author is of opinion that the electric furnace is especially suitable, and will be widely adopted, for any class of work in which raw materials of a high degree of purity are now used. A wider application for rails and sections may occur when working in connection with the Talbot furnace, for the charge can be taken to the electric furnace as soon as the carbon is down and the necessity of removing the sulphur and getting a teeming heat is avoided, as this is done in the electric furnace both economically and completely. Thus the capacity of the Talbot furnace is substantially increased, and this covers the greater cost of electric refining.

Again, in the case of a basic open-hearth plant, using 60 per cent of molten pig iron and 40 per cent of scrap, a 40-ton furnace might have 15 tons removed to the electric furnace for refining, and a similar charge put in every two hours. Thus the capacity would be increased, the quality improved, and, in addition, a reduction in the cost of raw materials can also be made in some cases, as a low quality of pig iron can be used.

Similar conditions occur when working in conjunction with an open-hearth plant for making castings, and a thoroughly dead melt and extreme fluidity can be obtained, while the commonest raw materials can be used, and refined completely. This gives economy both in the amount of gits and runners, and also in the reduction of wasters. Even in the case of foundries engaged in ordinary open-hearth casting work, in which the margin of profit is now exceedingly small, the electric furnace is considered necessary for an improvement in quality, while in a small foundry making light and intricate castings from crucible steel, an economy of several pounds per ton may be expected to result from the adoption of the electric furnace, judging from the reduction of the costs in works in Germany where crucible furnaces were replaced by this process.

There is little doubt that crucible steel, Swedish billets, and products of intermediate quality, such as are used for the Sheffield trade and by tube-makers of Staffordshire and South Wales, can be economically replaced by steel refined by electricity, and made in Middlesbrough, Cumberland, or the larger steelworks in the Sheffield and Rotherdam districts.

The use of the electric furnace is not likely to become general for rail steel manufacture at the present time, except in cases where the conditions are exceptional. In certain cases, such as at South Chicago, it has been adopted for that purpose owing to the economic conditions, notably the scarcity of good Bessemer ores and the demand for better rails. The electric furnace in such cases may save Bessemer plants from the scrap heap, or, at any rate, prolong the life of present installations, and at the same time make it possible to produce rails of a quality better than the best open-hearth steel, thus avoiding heavy capital expenditure.

In the electric furnace, almost any degree of refining can be economically effected, and the removal of sulphur, phosphorus and oxygen is especially easy. This is probably due to at least three causes:

1. The intense heating of the slag, which is the place at which refining takes place. Owing to this high temperature and the extreme fluidity of the slag the rate of the refining reaction is very great, because the velocity of reaction rises very quickly for high temperatures and not in direct proportion to the temperature.

2. The extremely basic slag that can be kept in a very fluid state, and the calcium carbide formed by the action of the arc on the calcareous slag, are especially advantageous for desulphurization.

3. The violent motion of the steel, which results from the convection currents produced in the bath, due to the two intensely hot areas caused by the arcs below the electrodes, increases the volume of steel exposed to the hot and fluid slag area, and hence the rate of refining.

The usual procedure for the use of the electric furnace in connection with the Bessemer converter is to charge the steel, holding back all slag in the ladle, after putting on the bottom of the furnace, lime and mill scale or iron ore. This produces an oxidizing or dephosphorizing slag, which may be carefully skimmed

*Paper read at the Buxton, England, meeting of the Iron and Steel Institute, Sept. 26-30, 1910.

or poured off. On the bath of steel carbon is thrown to carburize to any required degree, and then a second highly basic and desulphurizing slag is added. The arc acting on the calcareous slag produces calcium carbide, which may combine with sulphur to form calcium sulphide. As neither gases nor air enter the furnace, and the conditions are almost completely reducing, no sulphates are formed, a dead melt is easily obtained, and when the slag is molten and the requisite heat obtained, the steel is teemed. In the open hearth or any oxidizing furnace these reactions cannot take place so completely and efficiently.

With steel from the basic open-hearth furnace, the procedure is similar, but when the quantity of phosphorus to be removed is small, it is only necessary to use one refining slag for the elimination of sulphur and any small amount of phosphorus remaining. The usual practice is to put the carbon necessary for carburizing in the bottom of the furnace and then add the steel, and the basic slag materials. As soon as the teeming heat is obtained, the necessary ferroalloys are added and the steel will be completely refined.

Another point of interest is the rarity of blowholes in electric steel when properly made, and this leads to the question of the cause of these troubles. It is well known that any ingot of steel when placed in a vacuum evolves nitrogen, and this is about equally true whether it be made in the crucible, the Bessemer converter, or the electric furnace. Blowholes contain nitrogen, but this is probably not the cause. It is far more probable that they are due to the combination of oxides with the carbon in the process of cooling, and that the carbon monoxide so formed at a high temperature causes blowholes in the cooling steel, and owing to the diminution of volume of the carbon monoxide on cooling, a partial vacuum is formed, and nitrogen is sucked into the blowholes. In electric steel, oxides do not occur in any quantity, and consequently the prime cause of blowholes is reduced.

Again, the quality of electrically refined steel is better than a material of similar chemical composition made in any oxidizing furnace. This is probably due to the reducing conditions under which it is finished.

It must not be forgotten in discussing these special qualities of electrically refined steel that some inferior material has been made by incompetent melters or in ineffective furnaces, and that the electric, just as much as any other furnace, requires trained men, and most careful designing by metallurgists who have made a special study and had practical experience in this subject.

The question of the cost of applying this process, which must be considered before all others, is more difficult to discuss generally, owing to the great variety of conditions. The following are the chief points, all of which must be carefully considered in each particular case:

1. The possibility of saving in cost of raw materials, since the best qualities of steel can be made from impure raw materials. For example, in the case of refining steel from open hearth furnaces in the South Staffordshire district, the use of local pig iron as compared with hematite iron would effect a saving of several shillings per ton owing to the high railroad rates.

2. Possibility of increasing the output of present furnaces by the addition of electric furnaces with improvement of product. For example, in the case of Talbot and other open hearth furnaces, where a large expense is incurred in the removal of sulphur and getting a teeming heat, the steel can be advantageously transferred to an electric furnace for desulphurization and the output materially increased. The Talbot or other tilting furnace is especially satisfactory owing to the facility with which charges can be transferred to the electric furnace whenever required.

3. Cost of power and possibility of using blast furnace or coke oven gas, exhaust steam, etc., will be the determining factor in regard to deciding whether, in the manufacture of steel, electric refining can be economically adopted. In the case of cheap power for valuable products, scrap may be economically melted and refined in the electric furnace at a current consumption of 700 to 800 kw.-hours per ton, or if the price of power be high, the steel may be merely desulphurized and deoxidized, after melting and dephosphorizing in a basic furnace, with a power consumption of 100 to 150 kw.-hours per ton.

4. The possible reduction of capital expenditure at certain works where the present products are not sufficiently good for modern specifications. This may involve the entire reorganization of the works, but it is often cheaper and more efficient to add an electric furnace to a Bessemer plant than to replace the latter by open hearth furnaces.

The author does not wish to compare the different types of electric furnace in this paper, but the figures given are taken chiefly from Heroult furnaces in America, England, Germany and France, as this type has been far more widely adopted, and is used in larger units than any other, and single furnaces are now refining 250 tons per day. This furnace is similar to a basic open hearth furnace, and seems to present more simplicity and to embody more of the desirable features of electric furnace design than any other, which, in the author's opinion, are:

1. The best basic open hearth design should be followed as closely as possible. A bottom homogeneous and solid and banks free from embedded electrodes is important, and above all, simplicity of design.

2. All electric mechanism, in the form of generators, transformers, etc., should be entirely separate from the furnace, should work under ordinary conditions of standard electric practice, and should be of standard design, so as to avoid all unnecessary risks and complications.

3. A high power factor must be maintained, thus reducing the capital cost of machinery and increasing the general efficiency of the power house.

4. To avoid excessive cost of refractory materials, the roof should be protected from the direct radiation of the arcs by the electrodes themselves, and the intensely heated area of slag should be as large as possible, to increase the surface of refining action. The Heroult furnace has an advantage over the open hearth furnace in that the heat is applied to the center of the bath, so that the banks are not quite so hot as the middle of the furnace and the wear of refractories is consequently less.

5. The heat should be applied to the slag, as in the basic open hearth furnace, and the temperature of the slag should be maintained above that of the steel, which allows of extreme basicity and fluidity being obtained and gives an intensely active refining action. The conditions in the furnace should be oxidizing, neutral or reducing, at will.

The adoption of electric refining will cause some readjustment in the steel trade. As soon as the Sheffield steel melter has become acquainted with the process and accustomed to the working of electric furnaces, electrically refined steel will largely replace ordinary crucible steel. This has already occurred in Germany and America, where electric furnaces are used to make all classes of special and high-speed steels, the usual practice being to refine metal from a basic open hearth furnace. Large crucible plants and small open hearth furnaces engaged in the manufacture of small and intricate castings, such as motor car parts, etc., may be replaced by electric furnaces, because the high degree of fluidity and dead melt obtained is especially advantageous.

In many cases manufacturers of axles, guns and tubes will abandon the use of Swedish raw materials and refine steel made from low-grade ores, thus reducing the value of high-grade ore deposits and the quantity imported; for, by the use of electricity, Cleveland stone will produce a steel equal to the best hematite ores. The capacity of many Talbot and basic open hearth plants will be increased and the quality of the product improved, while much of the power that is now going to waste will be utilized for steel refining.

From the electrical engineer's point of view, the electric furnace is an attractive load, as it is more or less in continuous operation. In the case of the Heroult furnace the power factor is 0.88 to 0.90, though much less with large induction furnaces. Single, two or three-phase current of any frequency from 20 to 60 has been used without difficulty, though it is preferable in the case of a two-phase system to transform to three-phase current, which can be done without additional difficulty or expense. The load factor will be most favorable, the usual practice when refining, for example, in a 15-ton furnace, being to use 2,000 kw. for 20 minutes after charging, while the steel is being heated. The current is then reduced to about 1,500 kw. for 45 to 75 minutes until the steel is ready for teeming. There is then an interval of 10 to 15 minutes, during which the furnace is teemed, fettled and charged, which allows the transformers or generators time to cool before the period of overload commences. Current fluctuations occur for a few minutes, while there is an evolution of gas from the steel which makes the bath boil up and touch the electrodes. This, however, is not sufficient to be objectionable, provided that the electrical machinery is properly designed for the purpose, and the extent of these variations is not so great as in the case of many rolling mills, the fluctuations in voltage being only about 3 per cent in the South Chicago works, where a 2,000-kw. furnace has been working steadily since May, 1909.

THEORETICAL CONSIDERATIONS OF THE CUPOLA MELTING PROCESS.*

Dr. H. Holm of Nurnberg, Germany, discussed the cupola melting process from the theoretical standpoint in *Stahl und Eisen*. He compares the phenomena occurring in the lower part of the cupola with those in the corresponding portion of the gas producer. In a shaft furnace with a grate, using coke for fuel and with a regular air supply and removal of slag, the temperature of the various gases should remain continuously constant. It has been shown that with the temperatures existing above the grate of a producer, the union of the oxygen of the air with the carbon of the coke is very rapid; the maximum production of carbonic acid is found but a few inches above the grate, the exact distance depending upon the blast pressure and the character of the coke.

Again, the higher the temperature, after the oxygen has been used up, the quicker will there be a taking up of more carbon from the incandescent fuel to make carbon monoxide. This renders a quantity of heat latent and means a reduction in the temperature. From the analysis of the gases and their specific heat some calculations of interest can be made. The same amount of carbon burned to carbon monoxide and to carbon dioxide gives heat quantities of 1 to 3.26, and by dividing the heat quantity by the specific heat the temperature can be found. In the case of the cupola the formula would be arranged to take into account the varying percentages of the two gases for different points and then making certain deductions for heat losses.

Le Chatelier has worked out a table for the specific heat of carbon dioxide at varying temperatures, as also for the so-called permanent gases (carbon monoxide and nitrogen) in the cupola. This table plotted as a diagram shows the remarkably high specific heat of carbon dioxide, as against the values for the permanent gases. Now, from these things the author has constructed a diagram showing the average specific heat of cupola gases with carbon dioxide running as high as 27 per cent—the maximum limit when carbon is burned in air. This diagram also takes into consideration the variation in the specific heat of the gases

*From The Iron Age.

at high and low temperatures. Taking, for instance, a composition of the gases of 15 per cent carbon dioxide and 11.3 per cent carbon monoxide, with nitrogen at 73.7 per cent, the calculated temperature theoretically would be 3,555 F. Practically, on account of warming up the coke bed, this temperature is somewhat reduced.

About 3 ft. above the layer of highest temperature in the producer the gases correspond to 2 per cent carbon dioxide, 34.3 per cent carbon monoxide and 65.5 per cent nitrogen. This corresponds to a temperature of 2,475° F., theoretically. On account of the warming up of the coke bed, however, this is reduced to 2,100° F., and from this a small item for radiation should be subtracted. This shows, by comparison with the cupola, that at such a distance above the melting zone, there will exist temperatures considerably lower than the melting point of the metal itself. The highest temperature in the cupola is where there is a maximum of carbon dioxide.

In operating a cupola practically it is impossible to do without making some carbon monoxide. Only those temperatures above the melting point of iron will be useful for melting purposes; the rest serve only to preheat the charges. The charges should, therefore, be melted as closely as possible to the zone of maximum carbon dioxide. The iron melts fastest here, and is also hottest. If it melts above this zone it cannot acquire as much temperature, and in trickling down through the coke will not take up much extra. Hence dull iron with excessive coke beds. The nearer the metal gets to the high temperature zone, the faster the melting, the less sulphur absorbed, and the better the slagging off of sand, etc. The position of the zone depends upon the blast pressure and the character of the coke. The amount of air blown in determines the heat produced, and this the quantity of iron melted. Again, the velocity with which the air enters—it should be distributed evenly around the cupola—determines the necessary thickness of the bed above the tuyeres. A second row of tuyeres, not too far above the first, can be of use in burning up to carbon dioxide the carbon monoxide formed, more particularly in the case of poor cokes.

Wet air for the blast is unfavorable, the dissociation of the moisture taking up heat just when it is required most. This accounts for poor heats on moist or rainy days in contrast to cold, clear ones. Heating up the blast looks advantageous theoretically, but is questionable practically. Only in the case of continuous melting in large cupolas will it be worth while to make experiments in this direction.

Coke should be large, smooth and sound, apart from its chemical composition. The smaller and more cellular, the less the chance for proper burning up, and hence reduction in the rate of melting. As stated above, too high a coke bed means that for every pound of the coke burned in the zone of highest temperature, another pound is taken and dissolved to make carbon monoxide higher up, and hence lost for economical melting. In taking up this extra pound of coke, the bed sinks, iron begins to melt, and finally arrives at the point of quickest melting, unless by this time the next intermediate charge of coke is down and brings the bed up too high again. The result is poor melting and dull iron, which is accentuated if the intermediate charge of coke is also too large.

Too low a bed means that the highest temperatures possible in the cupola are not realized, on account of an overplus of air, which means iron getting below the melting zone, necessitating dropping the bottom. Wet coke cuts no special figure in melting, as it is dried before it gets down to the critical point for melting. The crucial part of the whole discussion, according to the author, lies in the character and depth of the coke bed, everything else being equal.

DETERMINATION OF FILLERS IN RUBBER MIXTURES.*

The present methods for the determination of filler in rubber viz: boiling with petroleum or with xylol under pressure are of little use if the rubber contains any easily decomposed sulphides as antimony sulphide in red rubber or carbonates which easily give off CO_2 as $MgCO_3$. For such cases it seems necessary to look for a solvent which will dissolve the rubber at temperatures below the decomposing temperatures of the fillers.

The D. R. P. 202850 pertains to a process for the regeneration of old rubber by treatment with high boiling ethers of the aliphatic, aromatic and of the heterocyclic series at 100° to 130° and the subsequent precipitation of the rubber by means of alcohol.

It seemed possible that this process could also be used in the analysis of rubber goods.

A series of trials has shown that by extended heating with Anisol or Phenetol (fatty aromatic) ethers at 90° to 120° good vulcanized para rubber can easily be brought into solution. The antimony sulphid remaining behind remains unchanged (its decomposition point is 130-140°)and also retains its red color. The magnesium carbonate is also unaltered. The determination is carried out as follows:

The finely divided rubber is leached with acetone to remove all free sulphur. 1 gm. of the extracted rubber is warmed to 90-120° with 30 ccm. of Anisol or Phenetol in a weighed Erlenmeyer flask of about 200 ccm. cap, till the rubber is all dissolved and the antimony sulphid and other fillers are on the bottom of the flask. For this from 1 to 2 hours is necessary, depending on the rubber itself.

After solution the flask is nearly filled with benzene and the mixture centrifuged. The clear liquid is poured off the residue, washed a few more times with benzene, and finally centrifuged with alcohol and ether. It is then dried at 105° and weighed. Some of the results will soon be published in "Die Mitteilungen aus dem Kgl. Material-prufungsamt."

*Translated from the Chemiker Zeitung for the Chemical Engineer.

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NOTES AND COMMENTS.

THE ENGINEER AND PUBLIC AFFAIRS.

That engineers fail to take an adequate part in political activities, and in the solution of the social and economic problems that confront us, is the basis of a "Criticism of the Engineering Schools," by Professor Dugald C. Jackson of Boston. The fault is laid in great part to the professional schools, their courses of study, and the failure of their directors to see clearly the full function of the modern engineer.

"It is an easy answer," says Professor Jackson, "to say that the engineers are too busy in working and directing the economic advances of civilization to afford attention to the way in which political and civic activities are guided; but this answer is inadequate. The lawyers, the physicians, the merchants are also busily engaged in affairs of importance, in their kind and they might make a similar excuse for abstaining from political and social activity; in which case, I think we must all admit, our forms of government would soon break down from want of adequately trained and disinterested leaders. This rather general failure of the engineering graduates to keep a wide-open eye on the political activities of our land is a serious fault that must be laid at the door of our education."

"That this is a fault which may be corrected," says Professor Jackson, "is apparent when one thinks of the number of graduates of the Polytechnic School in France who have not only become distinguished in science and engineering, but have also made strong impression on the nation's affairs. However well a man knows the physical and mathematical sciences," declares Professor Jackson, "he cannot make the most of his abilities as an engineer unless he also understands the human character and the trend of human progress. The study of historical and economic subjects is of an importance in the engineering curriculum that rivals the study of science subjects; and in order that the relations to each other of engineering science and political economy may be understood and appreciated by the students, the study of such subjects may preferably be carried on side by side. An industrial engineer must know the thoughts of the world, the flux of society, the ambitions of nations."

THE VALUE OF THE CHEMIST TO HIS INDUSTRY.

These remarks are called forth by the address of Professor Jackson, abstracts from which just precede the comments. It is the opinion of the writer that the chemist and chemical engineer can be criticised on the same lines in which Professor Jackson makes his criticism on the engineering profession in general. The present statements will be confined to discussing the relations between the chemist and chemical engineer and their industries. A recent conversation with a chemist who has general connection with a number of chemical industries, elicited the statement that he believed the failure of the chemist and the chemical engineer to advance more rapidly in their profession was due primarily to their narrow view and understanding of the industries with which they are connected. They were satisfied to do the work which was turned over to them in the laboratory and did not seek to familiarize themselves with the plant conditions which made this work necessary. They lacked any broad knowledge of the industry which might enable them to see the connection between this work and the actual manufacturing operations with which they are connected.

This is rather a severe criticism, yet the writer's experience and information would lead him to confirm, in a general way, this statement.

The man connected with any industry should take sufficient interest in its and his own advancement to familiarize himself not only with the plant operations in which he has a part, but also with the general trade conditions upon which the existence of this industry depends. He should know something of the trade demand for the products of his industry, so that he may be able to forestall any new advancement which may arise. It is only in this way that new and desirable products can be brought on the market. We must admit that in many cases this will be a difficult matter to bring about. The prime reason for the difficulty being that there is not the active co-operation between the manufacturing part of the plant and the chemical force which there should be. This is emphasized in the statement made in this issue, regarding the young chemist connected with a glass industry. The writer is of the opinion, however, that this is an extreme case and one which is not often experienced in the manufacturing industries.

It has been the writer's experience that the men connected with the actual plant operations are only too glad to have the assistance and co-operation of the chemist and chemical engineers, and to furnish any information which may be at their disposal; provided this information is sought in the proper manner. We must realize, however, that there are many ways in which this information may be sought.

Too many times we see a young graduate in chemistry or chemical engineering who goes into a plant and thinks he can tell men who have been connected with the industry for years how their work should be

carried on. Antagonism is, of course, aroused at once and the future value of the young man to his company is materially reduced. The young graduate makes a mistake if he does not go into his chosen industry with the idea that he is yet a student and has much to learn. He must feel his way slowly until he has secured the respect and confidence of his associates. It is only in this way that he may be able to perform his proper part in the industry with which he is connected.

THIRD ANNUAL MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The third annual meeting of the American Institute of Chemical Engineers is to be held in New York City Dec. 7 to 10th. The convention will be opened at 9:30 a. m., Dec. 7, at the Hotel Astor. Following the business session the following papers will be read:

Report of Committee on Chemical Engineering Education. F. W. Frerichs.

The Development of the Chemist as an Engineer. Dr. Fred W. Atkinson, President of the Brooklyn Polytechnic Institute.

The Training of Chemical Engineers which meets the Requirements of Manufacturers. Prof. M. C. Whitaker, Columbia University.

The Fitzgibbons Boiler. Jerome Alexander.

In the afternoon there will be an excursion to the Marx & Rawelle Glycerine Refinery in Brooklyn, N. Y. The evening meeting will be held at Columbia University. At this meeting a paper, "Manufacture of Hydrated Lime," will be presented by Richard K. Meade and an address of Chas. F. McKenna on "The Evolution of Portland Cement Processes" will be given. The second day of the meeting will be devoted to excursions, the Chamber Acid plant of the Standard Oil Co., at Bayonne, N. J., being visited in the morning and the Borough of Richmond garbage destination in the afternoon. In the evening there will be a subscription dinner at the Hotel Astor. The third day of the meeting will be devoted to the installation of officers and the reading of papers, the following papers being on the programme for this day:

Manufacture of Lignite Briquettes. Henry S. Renaud.

Bleaching Oils with Fuller's Earth. David Wesson.

Action of Fruit Juices on Metallic Containers. Edward Gudemann.

Vacuum Distilling Apparatus. Phillip B. Sadter.

In the afternoon there will be an excursion to the candle house of the Pratt Works of the Standard Oil Co., at Blissville, L. I., and to the grease works of the same company at Blissville. In the evening a joint meeting will be held with the New York section of the American Chemical Society, and the following papers will be read:

The Principles of Sewage Disposal. Geo. C. Whipple.

Sewage Disposal in Europe. Rudolph Hering.

Sewage Disposal in New York and Vicinity. Dr. Geo. A. Soper.

Sanitary Conditions in Their Relation to Water Supplies in the Vicinity of New York. Nicholas S. Hill, Jr.

The Unsolved Problems of Sewage Disposal. Prof. Chas. E. A. Winslow.

The last day of the meeting will be devoted to an inspection of the Chemical Museum and Laboratories of Columbia University and to the Chemical Building and Laboratories of the College of the City of New York.

RECENT PATENTS.

The following patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill Bldg., Washington, D. C.:

969,853. Method of Making *Liquid Sodium Amalgam*. Herbert P. Ewell, Detroit, Mich. Filed Jan. 2, 1909. Serial No. 470,427. Patented Sept. 13, 1910.

969,885. Process of Making *Sodium Cyanid*. Otto Liebknecht, Frankfort-on-the-Main, Germany, assignor to the Roessler & Hasslacher Chemical Co., New York, N. Y., a corporation of New York. Filed Feb. 28, 1910. Serial No. 546,189. Patented Sept. 13, 1910.

969,907. Method of Recovering *Ammonia* from Coal Gases and the Like. Jan Adolf Roelofsen, Middlesborough, England, assignor to the Actiengesellschaft fuer Kohlendestillation, Dusseldorf, Germany, a corporation of Germany. Filed April 19, 1910. Serial No. 556,402. Patented Sept, 13, 1910.

970,029. Process for making *grapesugar*. Gosta Ekstrom, Limhamn, Sweden. Filed Aug. 22, 1907. Serial No. 389,608. Patented Sept. 13, 1910.

970,325. Process of Treating *Ores*. Edwin B. Goodwin, Ward, Colo. Filed Oct. 14, 1908. Serial No. 457,667. Patented Sept. 13, 1910.

970,364. Process for *Distilling Coal*. Jonas W. Aylsworth, East Orange and Frank L. Dyer, Montclair, N. J. Original application filed May 25, 1906. Serial No. 411,840. Patented Sept. 13, 1910.

970,439. *Ink*. Wm. G. Fuerth, Newark, N. J., assignor to Equilibrator Co., Newark, N. J., a corporation of N. J. Filed June 26, 1906. Serial No. 323,533. Patented Sept. 13, 1910.

970,718. Method of Treating *Milk*. Samuel Ridgway Kennedy, Philadelphia, Pa. Filed June 1, 1906. Serial No. 319,671. Patented Sept. 20, 1910.

970,719. Method of Treating *Milk*. Samuel Ridgway Kennedy, Philadelphia, Pa. Filed June 1, 1906. Serial No. 319,672. Patented Sept. 20, 1910.

The Persian Government has modified its decision of January 9 last, and has postponed until the first of the month of Radjob, 1330 (some day in June, 1912), the date upon which, in accordance with the customs regulations, article 29, the exportation of carpets and rugs (tapis) dyed with aniline colors or colors in the composition of which aniline enters shall be rigorously prohibited. Some exports to the United States had been held up on this account.

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NOTES ON THE CORROSION OF IRON AND STEEL AND ITS PREVENTION.

By G. W. THOMPSON.

It is not my intention in this paper to discuss the various theories which have been advanced regarding the corrosion of iron and steel or even to discuss in detail the corroding operation. This subject has received very general consideration; and while there are differences as to matters of theory, there is fair agreement as to facts. It will not be possible for us to divorce the description of facts entirely from the terms which theory has given us, and we shall not hesitate to use these terms when occasion warrants it, simply asking that, if the reader does not accept the theory which is responsible for the terms he shall translate these terms into such other terms as more nearly agree with his theoretical conceptions.

By the corrosion of iron and steel, we refer to the oxidation which takes place at ordinary temperatures, with the formation of rust. Rust approximates the following formula, $Fe_2O_3.3H_2O$, although all rust does not exactly conform to this formula.

A sample of rust, obtained by exposing a thoroughly cleaned piece of steel, that is, a steel which had been pickled to remove scale, etc., analyzed as follows:

	Per cent.
Hygroscopic moisture	8.83
Combined water (including CO_2 0.17 per cent)	21.45
Ferric oxide (equivalent to iron 48.28 per cent)	68.97
Silica	.26
	99.51

The ratio between the combined water and the ferric oxide corresponds, approximately, to the chemical formula given.

It is to be noted, however, that, in addition to what is known as the combined water, it contains a relatively large amount of hygroscopic water. The nearly 9 per cent of hygroscopic water shown in the above analysis corresponds to nearly 30 per cent of water by volume.

A very important consideration in connection with the formation of rust is: The specific gravity of iron is about 8.70, and the specific gravity of rust is about 3.70. If the iron and the rust are strictly pure and of theoretical composition, the iron shows an increase in volume in conversion to rust equal to 336 per cent; that is, 100 parts of iron become 436 parts of rust by volume.

Often, rust has associated with it the mill-scale, which is formed in the process of rolling or other hot treatment—this scale consisting of slag and oxides of iron, more or less similar to magnetic oxide.

If we consider a rusting surface together with its atmospheric surroundings as a material system, corrosion may be due to forces operating within that system or to forces coming from without the system such as stray electric currents. Corrosion of the former kind should be considered as primary corrosion and the latter kind, secondary corrosion. Primary corrosion may also be considered as autogenous. In the terms of the electrolytic theory of corrosion, primary corrosion is due to primary or autogenous electrolysis, while secondary corrosion is due to secondary electrolysis.

The prime material factors in corrosion are air and moisture, and the action of air and moisture is accelerated or retarded by other factors.

The tendency of iron to corrode has been considered to vary with the composition of the metal, but, apparently, facts do not warrant this conclusion to an extent that would justify general dependence on a purer and more expensive metal as against a more impure and cheaper metal. Practical experience may in some cases justify such a dependence in isolated cases, but not as a general rule.

Nevertheless, corrosion, which usually takes place in the form of pitting, is unquestionably due to the greater tendency of the pitting parts to corrode than the adjacent parts. Such corrosion is said to be due to a higher electrolytic solution pressure as compared with the adjacent parts, and the corroding area is said to be electro-positive to the surrounding area. This, of course, refers to primary corrosion, to which most of our remarks will be directed.

The corroding operation is supposed to be, first, a solution of the iron in the water and, second, the oxidation by the air of the dissolved iron, with the formation of ferric hydrate or rust. This solution would not take place without the water being present, nor would the oxidation take place in the absence of air. The solution of the iron is accelerated by the presence of carbonic or other acids and neutral salts, also by the presence of substances which are electro-

*Paper read before the American Institute of Chemical Engineers.

negative to iron. The corrosion is furthermore accelerated by the presence of substances or conditions which increase the amount of moisture on the surface, as by hygroscopic substances such as rust itself or a moist atmosphere.

The oxidation of the iron is accelerated by the presence of oxidizing or depolarizing substances. Ferric hydrate can give up a portion of oxygen to iron, being reduced to ferrous hydrate, or it can act as a depolarizing agent by oxidizing the hydrogen supposed to be liberated by the solution of the iron in the water.

The acceleration of the corrosion of iron by the presence of acids is supposed to be due to an increased concentration of the hydrogen ions. Whether this is so or not, it is found that the presence of substances which are supposed to decrease the concentration of the hydrogen ions, that is, increase the concentration of hydroxyl ions, tends to retard corrosion. Iron does not rust in solutions of alkali of sufficient concentration.

Let us summarize these causes of corrosion and, in general, the methods which can be suggested for its avoidance:

1st. Corrosion is superficial; therefore,

(a) The area of the surface is a positive factor in corrosion, and

(b) The prevention of corrosion is most naturally accomplished by superficial protective coatings.

2d. Corrosion is an oxidizing action; therefore, oxygen and substances that liberate oxygen under ordinary conditions should be kept away from the surface subject to corrosion as far as is practicable.

3d. Corrosion starts with the solution of the iron in water; therefore, moisture and moisture-absorbing or hygroscopic substances should be kept away from iron and steel, and furthermore, as the tendency of iron to go into solution is variable, the surface should be made as passive in this respect as is possible.

4th. Corrosion is accelerated by the presence of acids, the most prevalent acid being carbonic acid; therefore, acids, especially carbonic acid, should be kept away from the surface, and furthermore, as alkaline solutions of sufficient concentration retard corrosion, their presence should be favored, unless good reasons exist to the contrary.

5th. Corrosion is accelerated by the presence, on the surface of the metal, of substances, whether a part of the iron or not, that have lower solution pressures than the iron; therefore, such substances should be eliminated.

6th. Corrosion is assisted by the presence of depolarizing substances which, in general, are substances that under ordinary conditions are capable of reduction. Especially is this so when the depolarizing substance is one that is capable of regeneration by oxidation. Rust itself is a depolarizing agent of this character, and, therefore, rust and similar depolarizing substances should be kept away from the surface.

In this paper, we are using theory only so far as it will guide us to practical results. We have endeavored to outline all the known causes of corrosion and its prevention, and we will now study these causes and the methods available for their prevention a little more in detail.

Corrosion is superficial. The constructing engineer should keep this constantly in mind and should design structures with as little exposed surface as possible. This he can do, of course, only in so far as such design is consistent with strength, flexibility and appearance, giving, where other things are equal, a preference to the design that has the smallest amount of superficial area. We believe that much structural steel work of the lattice type, if considered from this standpoint, would be condemned and that plates would be used in place of lattice work to greater advantage. Rounded or flat surfaces should be given the preference over angular surfaces, whether in relief or in recess. A square bar has over 12 per cent more surface than a round bar of the same sectional area. Furthermore, a rounded section is less subject to erosion than an angular section. It is the edges of painted structures that wear off the soonest and which corrode the most quickly. So, too, the smoother a surface is, the less is its superficial area. A rough surface is doubly bad, because, in addition to its relatively high area, the indentations form moisture-holding pockets.

Effective protective coatings are of two general types, excluders and inhibitors, although it is probable that no protective coating is entirely one or the other. Tin on tin plate is principally an excluder, while zinc, in the case of galvanized iron, is principally an inhibitor. The best plan would appear to be to have the interior coating an inhibitive coating, and the exterior, an excluding coating. Thus, if it were practicable to place a tin coating on galvanized iron, a combination of excluder and inhibitor would be obtained.

In the painting of iron and steel, several distinct subjects present themselves for consideration:

1. Cleaning the metal.
2. Design of paint coatings.
3. Application of paint.
4. Repainting.

Various methods have been proposed for the cleaning of iron and steel. These may be considered under the following headings:

1. Shop cleaning with wire brushes.
2. Pickling.
3. The sandblast.
4. Cleaning with wire brushes on or after erection.
5. Cleaning by exposure to remove mill-scale, with the subsequent use of wire brushes, etc.

There can be no question that iron and steel should be as thoroughly cleaned at the shop as possible. We have a feeling that more attention at some time in the future, will be given to this phase of the subject and

that the producers of steel will work towards the production of a polished surface.

There is no better method of cleaning small objects than by pickling. The following procedure has been found satisfactory:

Dip the articles, if at all greasy, in a hot 10 per cent caustic soda solution; then in hot water; then for, say, ten minutes in hot 10 per cent sulphuric acid; then in hot water; then in hot 10 per cent carbonate of soda (soda ash) solution; rinse well in hot water, and pack in slacked lime until time for painting has come. Remove from the lime; wash well with water; brush clean, and dry rapidly. The articles when dry will be ready to paint.

The use of the sandblast is seldom applicable. It is effective but costly. It is probable, however, that the sandblast removes considerable iron as well as objectionable substances.

The use of the wire brush and scraper, with the hammer where necessary, is the most practical way of cleaning, so far as the mechanical phase of the subject is considered. Mill-scale, however, is not readily removed by wires or scrapers. There is some difference of opinion as to the desirability of removing all the mill-scale. Our own experience is that mill-scale, unless completely removed, is apt to become loosened and to come off later on, carrying the paint with it in sheets. It is for this reason that the fifth method of cleaning has been suggested.

On exposing iron and steel to the weather, a certain amount of oxidation takes place, which is said to loosen the mill-scale so that it can be removed quite readily by wire brushes and scrapers. This system has been followed very generally in some sections of the country and has much to commend it, although, on the other hand, there are good reasons to be advanced against it. One reason for it is that, if the mill-scale should become loosened after painting, insidious corrosion could take place which would not be discovered for a long time. On the other hand, to expose the iron and steel to the weather involves the corrosion of good metal as well as the removal of the scale and makes the removal of all the rust so formed exceedingly difficult.

The proper cleaning and painting of large structures is often difficult on account of design. We would urge that painting is an important matter to consider by designing engineers and that such painting and the incident cleaning of the steel be contemplated in the design of the structure and made as easy as possible.

In the selection or designing of paint for iron and steel we believe that there are certain principles which should guide us. Protective coatings, as we have already indicated, may be considered as of two classes—inhibitors and excluders. For practical purposes, however, this division is not entirely satisfactory. It would appear better to consider paints according to the prime purposes for which they are applied. Classifying paints from this standpoint, they should be considered as protective or finishing paints. Protective paints are applied primarily for the protection of the iron or steel, while finishing paints are more for decorative purposes.

Considering protective paints, the principles which should guide us in their design or selection are as follows:

It is desirable that each coat of paint have a distinct color so that the painting can be inspected and imperfections in the workmanship observed. For this reason, it is not wise to select paints for all coats of exactly the same composition. By far the greater part of the failure in the protection of iron and steel by the application of paint is due to poor workmanship, and from this standpoint alone the selection of the color of each paint coating is an important matter. The use of linseed oil as a priming coat is to be condemned because it cannot be told whether good workmanship is being done or not. This applies also to all paints similar in color to the metal painted. Very often, a paint is condemned as being difficult to apply when in reality the difficulty lies solely in the fact that imperfections in workmanship are readily observable. In this sense, it is difficult to apply any paint that is distinct in color from the surface to which it is applied. The difficulty of application from this standpoint is a merit rather than a defect.

We have condemned the use of linseed oil as a priming coat for iron and steel for the reason that it is impossible to tell whether the application has been well made or not. But more important than this, a linseed oil priming coat should be condemned, for the reason that all under coats of paint should be as hard as possible, which is not obtained when a linseed oil priming coat is used. Whatever rust-preventing power subsequent paints may have tends to be nullified by being separated from the iron and steel by a linseed oil film. A hard protective coating gives the best possible foundation for a subsequent paint.

As far as possible, the pigments contained in protective coatings should be inhibitors of corrosion and non-conductors of electricity. The paint should contain no water-soluble constituents, especially such as are electrolytes. Paints which contain pigments containing electrolytes favor both primary and secondary electrolysis.

Protective coatings should be as impermeable as possible. To accomplish this end, each coat should have a reasonable thickness. If the paint is brushed out too thinly, one or more additional coats must be applied to give proper thickness of coating. The impermeability of paint is greater, the greater the amount of the pigment and the finer the pigment is; so that the rule may be laid down the higher the percentage of the pigment and the finer the pigment, the better will be the protective coating. Of course, you cannot increase the percentage of pigment beyond what will give a good working paint, and you cannot increase the fineness of the pigment beyond what will permit you to have a sufficient amount of pigment present.

From these considerations it would appear that the principles which should guide us in the selection or design of a good protective paint for iron and steel are:

1. Each coat of paint should be distinctive in color from that of the iron and steel painted and from the preceding coat.

2. It should form a hard adherent foundation for finishing paints.

3. Its pigment constituents should not accelerate corrosion.

4. The paint should insulate the iron and steel.

5. The paint should contain no compounds appreciably water-soluble.

6. The paint should be as impermeable as possible.

In considering these principles, we should bear in mind, however, that no one of them is a determining factor; that all should be considered together, each with its respective value. No protective coating should be judged by one quality alone.

Little can be said regarding finishing coats, as color is most often the determining factor. Black paints are much desired for finishing coats and they are excellent for this purpose, as they are usually fairly permanent and impermeable. Asphaltum should not be used in protective coatings, except to such an extent as it can be assimilated in varnish so that it becomes insoluble in further coats of linseed oil or other paint vehicles. The dark greens and olives are exceedingly serviceable as finishing paints. If a good protective paint is used, almost any reasonably good finishing paint can be applied.

Good workmanship in the application of paints to iron and steel is more important than the actual selection of the paint. Labor is the principal item of cost. Many a good paint has been applied by incompetent workmen, so that, in effect, both labor and material have been thrown away.

That portion of the Havre de Grace Bridge of the Pennsylvania Railroad, painted under the auspices of Committee E of the American Society for Testing Materials, is in excellent condition after 3½ years' exposure. There were 19 different paints applied and they were applied so well that practically all of them appear to be doing good work.

The proper inspection of a painting job is too often neglected. It is our opinion that painting inspectors should be more often employed than they are.

Corrosion is an oxidizing action, but, unfortunately, we know of no method of keeping oxygen from the surface of iron or steel except by means of protective coatings; and it is doubtful whether in this respect they are in any degree effective. But, as iron will not oxidize except in the presence of moisture, it would seem unnecessary to take any steps to exclude oxygen from the surface of the iron, while decided steps should be taken to keep out moisture. On the other hand, substances that liberate oxygen under ordinary conditions and become, in effect, depolarizing agents, should be kept away from the surface of iron and steel. This will, however, be spoken of further on.

Moisture is, however, something that should be kept as far away as possible from the surface of iron and steel. This can be done to some extent by protective coatings; and in the selection of those protective coatings, their moisture-absorbing or hygroscopic qualities should be considered. Unfortunately, very little or no work has been done on this subject. It is probable that a pigment which is hygroscopic before mixing with oil will remain hygroscopic to some degree after mixing with oil. It is probable, however, that some pigments by their action upon the linseed oil, may increase the hygroscopic qualities of the oil itself. The principal vehicle used in protective paints is linseed oil. It is a glyceride, and under some circumstances it becomes decomposed with the liberation of glycerine.

It would seem possible that glycerine, being a hygroscopic substance, would affect, to the degree that it is liberated, the moisture-absorbing quality of a protective coating. Much study should be given this phase of the subject.

The solution of iron and steel is the first step in corrosion, and has received considerable study in connection with attempts to make iron and steel passive in this respect. The most interesting work along this line has been done by Messrs. Cushman and Walker in the use of chromates. It is found that a clean steel wire, dipped for a few minutes in a solution containing chromic acid, does not rust so readily as before such treatment, and it will not precipitate copper from copper sulphate solution. The theory of this is variously expressed; and the reason why chromic acid acts in this way is all a matter of conjecture; the practical fact remains that chromic acid does make iron passive. It would appear that its electrolytic solution pressure becomes reduced nearly to zero, and that the solution of iron in water is a negligible quantity. It is impracticable to treat iron with chromic acid to make it passive, as this passive quality is evanescent. The best that has been suggested so far has been to introduce or use in protective coatings chromates which are sufficiently soluble to maintain this passive state. Many suggestions have been made along this line, none of which, however, has become of commercial importance. The field, however, is promising and it is to be hoped that something in the near future will develop.

In locations where the tendency is for the moisture contents of the air to be high, it would seem proper that steps should be taken to reduce that moisture to within reasonable limits. Everyone is familiar with the sensation indicating high moisture contents in the air of subways. It is uncomfortable to the traveler and not favorable to the protection of the steel columns and girders. This moisture can be reduced by systematic cooling devices and by the use of lime, etc., and should be done to a point where the cost would not become prohibitive.

In the design of iron and steel structures, proper thought should be given to the draining of condensed moisture or rain. The lower part of lattice columns should be filled with concrete with a crown to carry

off the water, and every other method that can be suggested should be followed as far as practicable to prevent water from remaining in pockets.

The acceleration of corrosion by the presence of acids and salts should be avoided by every practical means. In subways and other places where carbonic or other acid may be excessive in the atmosphere, lime should be freely used. It would seem possible to devise a system whereby lime thus used could be regenerated periodically. Where liquid acids are of necessity present, an attempt should be made to neutralize them by the use of alkali. In the case of refrigerator cars, which are thought to be the cause of much corrosion on steel bridges, special precautions should be taken to discharge the drip out of the range of the bridge or by some other means to prevent its dropping. The use of alkali and alkaline earths to prevent corrosion is effective as far as it goes. The embedding of steel in concrete is along this line. The practice of putting lime around the footings of steel columns is a good one. Lime may not exist in concrete in the free state, and yet there seems good reason to believe that, as far as results are concerned, concrete acts in the prevention of the corrosion of iron and steel just as caustic lime does. The aging of concrete and the aging of lime, however, result in the final neutralization of the caustic constituents by the absorption of carbonic acid, and carbonate of lime is not so effective in retarding corrosion as caustic lime is.

The acceleration of corrosion by the presence on the surface of iron and steel of substances which develop primary electrolysis, through their having a lower electrolytic solution pressure than the iron itself, should be avoided as far as practicable, but this is not saying much. We do not know of any practical method of securing such homogeneity as will not permit of local polarity being present. Unequal strains, inequalities in composition—all tend to develop local corrosion. The best that can be done here is to use protective coatings which keep out the agents of corrosion.

Acceleration of corrosion by the presence of depolarizing substances can be avoided principally in the removal, before painting, of rust and repainting wherever rust spots appear. Rust itself is the principal depolarizing agent in corrosion. Its alternate reduction and oxidation and its moisture-holding properties, make it very desirable that rust, as fast as formed, should be removed and the rusted surface painted. It is not always practicable to remove completely rust when once formed, but this removal should be as complete as possible.

Corrosion of iron and steel, as caused or accelerated by outside currents producing secondary electrolysis, is something that should be avoidable with comparative ease. The insulation of steel structures at their foundations, the proper insulation at joints, and the proper painting should reduce this damage to a minimum. This cannot, of course, be said in regard to water and other underground pipes. Here, the foe is insidious; and yet, careful measurements should be made from time to time and stray currents avoided. A phase of secondary electrolysis to which but little attention has been given is that which results from induced currents and such currents as may be generated through daily variations of terrestrial electricity. As far as these are concerned, it would appear that the only method for their prevention that can be devised is by protective coatings.

THE FORTY-THIRD MEETING OF THE AMERICAN CHEMICAL SOCIETY.

The forty-third meeting of the American Chemical Society will be held in Minneapolis, Minn., December 28 to 31, 1910. The headquarters will be at the Hotel Dyckman, Sixth street, between Hennepin and Nicollet avenues, and the meetings will be held in the Chemistry Building at the University of Minnesota. The program according to a preliminary announcement will be as follows:

On Wednesday, December 28, general meeting of the whole society will be held at 9:30 a. m. in Room No. 1, Chemistry Building, of the University of Minnesota. Several addresses will be given, among these being the following: Arthur D. Little, "The Basis of Industrial Efficiency"; Herbert N. McCoy, "Synthetic Metals from Non-Metallic Elements." At 2:30 p. m. an address will be given by President McPherson, Section C, American Association for the Advancement of Science, the title of his address being "The Formation of Carbohydrates in the Vegetable Kingdom." At 4 p. m. there will be a meeting of the Council, American Chemical Society. (This is contingent upon favorable action upon a letter ballot now before the Council.) At 8 p. m. there will be an address, "A Universal Law," by W. D. Bancroft, President of the American Chemical Society. A complimentary smoker will be held later in the evening.

The program for Thursday, December 29, includes the meetings of Divisions and Sections in the Chemistry Building, University of Minnesota. This will take place in the morning. During the afternoon there will be excursions, and in the evening a meeting of the Council will be held.

On Friday, December 30, a general business meeting of the American Chemical Society will be held from 9:30 to 10:30 a. m. At 10:30 a. m. the Division of Industrial Chemists and Chemical Engineers will meet in Room 1, first floor of the Chemistry Building. The special feature of this meeting will be an Efficiency Symposium. Short, straight and practical papers, telling how to prevent waste, improve a process or get better returns from materials, supplies, energy or labor, will be read. The Divisions of Agricultural and Food Chemistry, Physical and Inorganic Chemistry, and Fertilizer Chemistry and the Section of Rubber Chemistry will also hold meetings. The subscription dinner of the society will be held at 7 p. m.

The forenoon of the last day of the meeting will be devoted to adjourned meetings of the divisions

THE NATURE OF THE ACTION OF DYEING.*

By W. F. DREAPER, F. I. C., F. C. S.

Illustrated by—

(1) Dyeing silk, using amino compounds present in the fibre.

(2) Dyeing silk by the one-bath method (logwood and iron).

(3) De-solution effects with sand column.

(4) Cross dyeing effects: samples of materials.

In order to bring before your notice certain abnormal reactions occurring in the process of dyeing textile fibres, which may also throw further light on certain little understood conditions involved in the presence of colloids, I propose to give a short *resume* of some work undertaken on this subject by myself, or in conjunction with others. This has been founded to a large extent on observations made in the dye-house itself. It is treated under the following general headings:

Ingrain Colors.—It is well known that certain dyes can be found in the fibre substance itself. In this way, for instance, primuline is dyed on either cotton, wool, or silk; the fibre submitted to the action of a solution of nitrous acid to diazotise it, and the true dye subsequently formed by the action of solution of phenols, or amines, *in situ*.

A quantitive investigation into the relative fastness of these dyes against alkaline solutions,[1] indicated that they were invariably more resistant to resolution under the action of such reagents when produced, or built up, in the fibre area.

Such a result might follow from a possible increase in size of the dye aggregates formed in the interior of the fibre, or the greater insolubility of the new dye might produce this effect. It was noticed, however, that even when subjecting the dyed fibre to the action of solvent reagents in which the subsequent dye was exceedingly soluble, and presumably in a state of low aggregation, that the same result was obtained.

Abnormal conditions of dyeing were also observed with certain developers. For instance, *B* naphtol sulphonic acid (R salt) gave satisfactory results on cotton, but the dye was not formed or developed in the presence of the silk fibre. This possibly indicates some combination between the diazoprimuline and the silk, which is sufficiently stable to prevent the true dye being formed, as in the case when cotton is the fibre present.

As showing the possibility of chemical action occurring when dyeing animal fibres, the power that silk possesses of becoming colored during the above treatment in the absence of any primary dye may be instanced.

The sample of silk before you has been simply immersed in a weak solution of nitrous acid: it will now be introduced into an alkaline solution of *B* napthol. It immediately takes a dark red shade, as in the case of the primuline dyed sample. This dye is, however, not fast against the action of boiling soap solution.

The intervention of some active body, such as an amino acid in the animal fibre substance during dyeing operations, is perhaps discounted by the observations of Bentz and Farrell[2] that on the removal by reduction of any such groups the dyeing power of the fibre substance remains unaltered.

On the other hand, I shall be able to indicate that, as judged by ordinary standards, a close relationship exists between the fibre substance and the dye in a number of cases; and that this varies according to the conditions of dyeing in a definite and rather remarkable manner. These reactions are of interest from a general point of view, for they indicate that conditions obtain in the dyed fibres which may vary and be governed by the original conditions of application.

Fading of Picric Acid.—A change entailing loss of color occurs when picric acid is exposed to dehydrating agents acting through a vacuum. This has been ascribed to the suppression of free H ions. It was thought advisable to examine this "fading action" in the presence of fibre colloids, it being assumed that any retarding action observed might indicate the presence of some affinity between the fibres and the dye.[3]

No loss of color was observed when wool or silk dyed with this substance was exposed in a sealed tube over concentrated sulphuric acid in a high vacuum for sixty days; but under the same conditions gun-cotton (cellulose nitrate) lost 20 per cent of its color in ten days; artificial silk (hydrocellulose) 10 per cent; and cellulose and the picric acid itself 5 per cent. After sixty days' exposure the gun-cotton had lost 50 per cent, the artificial silk 30 per cent, the cellulose 25 per cent, and the picric acid itself 12 per cent.

It was also observed that silk dyed 98° C. showed no change after fifty-two days' exposure, while silk dyed to the same shade at 15° C, lost 12 per cent of its color. Here there is an indication of some closer relationship between dye and fibre, when dyeing takes place at a higher temperature.

With this dye, and under the conditions of the experiments, there is evidence that the presence of animal fibre substance retards fading, although the vegetable fibres act in the contrary direction. It may be noticed in passing that this result corresponds roughly with the relative dyeing power of this dye on animal and vegetable fibres respectively.

There is a maximum fading effect in every case due to a state of enforced equilibrium; the fading which took place at 150 days' exposure not increasing at 220 days, under the conditions of the experiment; but variations in temperature seem to greatly alter the rate of fading.

The color returns to its original shade on subsequent exposure to damp air, confirming the suggestion that the absence of water is responsible for the loss of color, by the suppression of free H ions, or

*Paper read before the Faraday Society, April 5, 1910.
[1]Dreaper, F. S. C. I., 13, 96.
[2]F. S. C. I., 16, 405.
[3]Dreaper and Stokes, F. S. D. & C., 1909, p. 10.

through some association action between the water molecules and picric acid.

The reactions between the fibre colloids and dyes of the "indicator" type have also been studied,[4], use being made of the well-known color reactions which occur with these dyes in the presence of acids or alkalis, respectively.

For instance, the reaction between methyl orange and sulphuric acid is altogether abnormal when this yellow orange dye is present on silk, as the following results will indicate:

METHYL ORANGE ON SILK.

Strength of Acid Solution.	Color Change. Fibre.	Color Change. Solution.
N/10 Sulphuric Acid.....	Pink	Pink deep.
N/25 Sulphuric Acid.....	Pink in 20 secs.	Pink deep.
N/50 Sulphuric Acid.....	Orange in 30 secs.	Pink
N/75 Sulphuric Acid.....	Yellow orange	Pink deep.
N/100 Sulphuric Acid.....	Yellow orange	Pink deep.

In a solution of N-100 sulphuric acid, which, of course, immediately turns the solution pink, the dyed fibre is practically unchanged in tone.

Similar results were obtained when wool was substituted for silk. The reaction with cotton could not be observed as this dye is not a 'cotton dye."

Using a "direct" or cotton dye (benzopurpurine 4B), a similar result was obtained, and a reaction took place on raising the temperature of the dyed fibre while still in the acid solution; a partial recovery in the direction of the original shade took place in the case of animal fibres and the reverse with the vegetable fibres. This indicates that the affinity between the dye substance and the animal fibre is materially increased at high temperatures, as there is no corresponding change in the color of the dye solution. All fibres dye under standard conditions to a deeper shade at higher temperatures, but that the above action is not due to some general dissociation effect, or a possible combination between the dye and acid, is suggested by the recorded fact that the dye in solution does not alter in shade in the same way between the limits of 15°-100° C., and also by the varying and opposite results produced with different fibres.

It was also observed that the free color acid of methyl orange is not red, as previously supposed, but orange; the red coloration obtained when this reagent is used in volumetric analysis being due to the formation of some loose combination between this free dye acid and the free acid in solution; this is decomposed in the presence of a large excess of water. When dyeing takes place out of this red solution the animal fibres are orange and not red. This is regarded as additional proof of some specific relation between the dye and fibre, definite enough to cause the decomposition of this red compound in the presence of a comparatively large excess of free mineral acid.

Even when dyeing in the presence of such an excess of free acid, that no such return of shade to orange was possible, the fibre still absorbed the dye. This may indicate that even if the mutual attraction between the dye and fibre is such that in the presence of a certain excess of free acid this orange "compound" is still formed, dyeing cannot take place entirely through the same group as plays part in the formation of the acid-additive compound. Or if so, that an equilibrium is established in which we have a small proportion of the dye in combination with the fibre substance; and that then through alteration in conditions governing the solution state in fibre area, the acid compound is again formed in quantity, and held against any resolution effect.

The corresponding reactions on vegetable fibres were modified in the case of such dyes as are indicators and will also dye cotton, but to nothing like the same degree, indicating that the affinity between the cellulose and dye (as tested from this standpoint) is less than with the animal fibres.

The action of the addition of salts to the dye bath is specific in the case of dyeing with cotton or "direct" dyes. It increases the amount of dye taken up by the fibre. The presence of salts retards the action of the acid on the dye, when present in the fibre. In one case (in cotton) twenty times the amount of acid in unit volume of dye-solution was required to give the same color change, so that in some way or other the presence of salt (*i. e.*, sodium chloride), which is known to greatly increase the amount of dye absorbed by the fibre, also prevents the color change with acid when the dye is once on the fibre; it would seem, therefore, that the dyes may be in closer relation to the colloid fibre substance in the presence of salts, and under these conditions when estimates in terms of the above color changes with acids.

Basic dyes also react in much the same way.

The nature of these general reactions with the indicator dyes in the presence of fibres may possibly be indicated by the fact that the equilibrium established between

$$\text{Dye} + \text{fibre} \rightleftarrows + \text{acid. aq.}$$

may be displaced in either direction according to the nature of the fibre present (on cotton one way, on wool or silk the other). The strength of the acid solution and not the direct ratio determined the equilibrium, which was of a reversible nature.

Temperature of Dyeing.	Loss of Color. In Soap-Solution at 100°.	In Alcohol at 80°.
90° C.	50 per cent.	84 per cent.
75° C.	70 per cent.	69 per cent.
60 C.	94 per cent.	92 per cent.
40° C.	96 per cent.	96 per cent.

It was shown also that an animal fibre could "fix" acid and dye successively, and hold these reagents apart within the fibre material, and prevent the normal color changes obtaining under these conditions.

On the other hand, solvent reagents of an akaline reaction indicate that the affinity of cotton colors for silk (of wool) is less than for cotton when expressed in terms of resolution into these reagents. Skeins of silk and cotton dyed with these dyes, and subsequently extracted with a solution of ammonium acetate, react in such a way that the dye leaves the

[4] Dreaper and Wilson, F. S. C. I., 1909.

silk and remains on the cotton. I suggest that there is evidence from the above results, when taken in conjunction with the results obtained by the action of acid, to indicate that the cotton dyes are held by the fibres in different ways. Or that this attraction is of such a nature that the dyes will subsequently react more readily in the case of the cotton fibre with acids, but less readily with alkalis. The work is still, however, incomplete, and I will defer further remarks on this subject for the present. Advantage is already taken of this last reaction in practical dyeing to obtain cross-dyeing effects on different fibres.

Resolution of Dyes Into Solvents.—It has been noticed[5] that the resolution of dyes, both acid and basic, into solvent solutions (such as alcohol or soap solution) varies inversely as the temperature of dyeing.

In the case of night blue on silk, for instance, the results obtained are given in the table opposite.

The results obtained with other dyes and fibres are of the same order.

For instance, with an acid dye (acid anthracene red 3B), the following results were obtained:

Temperature of Dyeing.	Loss of Color. In Soap at 55° for 30 minutes.	In Spirit at 55° C. for 1 hour.
90° C.	28 per cent.	24 per cent.
75° C.	48 per cent.	32 per cent.
60° C.	56 per cent.	44 per cent.
40° C.	95 per cent.	72 per cent.
18° C.	99 per cent.	92 per cent.

Similar results were obtained when cotton was dyed with benzopurpurine 4 B, although in this case alcohol at 15° C, after prolonged treatment removed the dye from all samples.

The Absorption of Dyes by Inorganic Substances has been studied in several directions. The special effects obtained by filtering through a column of purified and ignited silica (sand) have been investigated[6], and the results obtained may be noticed here.

In these experiments the solution (1 in 10,000) of certain dyes falls drop by drop from a graduated burette through a 5-in. column of sand contained in a glass tube of 5 to 10 mm. diam. The dye stuff is at first deposited on the surface of the sand particles, probably by a process of "absorption," and a perfectly colorless liquid passes out at the bottom end of the tub. As more of the dye solution is added the sand is progressively "dyed" throughout its length; finally the liquid passes through strongly colored. This transition from a colorless to a colored liquid is generally very sharp. A delicate means is thus afforded of comparing the relative "dyeing powers" of different dyes under these conditions, and possibly at the same time a method of ascertaining within certain limits their solution state is also obtained. The ratio—wt. of dye retained—wt. of sand—is a constant for each substance, at the point where the solution first passes through colored, so long as the same quality of sand is used. Increasing the size of the sand particles diminishes the value of this constant, showing that the action is a surface one.

The absorption of night blue by sand is very definite in its nature, and the dye is held against water, but not against alcohol. This action is sufficiently remarkable for it to be shown on this occasion. The end reaction is a very definite one, as will be seen from the following figures obtained in successive experiments with different weights of sand:

Ratio dye/sand	0.000148
Ratio dye/sand	0.000147
Ratio dye/sand	0.000148

The addition of sodium chloride to the dye solution of the "direct" dyes which dye cotton without a mordant gives a greatly increased dyeing effect. An increased absorption is obtained in the sand column with these cotton dyes, but not with picric acid, which does not dye cotton (cellulose) direct. In the former case the amount of dye held back by the sand column in a 10 per cent solution of salt is five times the normal.

This effect may be due to the decreased solubility of the dye under these conditions. The same effect is produced with night blue in a salt solution when near the salting-out point, although it does not dye cotton direct.

In the case of pseudo-solutions which are colored and in a state of high aggregation, the sand column is useful as an indicator. The top layer of the sand will then absorb an excess of the dye, or even the whole of it. This is readily seen by the color of the top layer. The lower portion of the sand column may or may not remain uncolored as the case may be. This deposition or de-solution may prevent the flow of the dye solution. The water will pass perfectly clear until its passage is entirely prevented by the deposited dye material.

This sand column may also be of value in generally separating colloids from their solutions and obtaining information as to their solution state. This matter will be investigated. In the above cases, at any rate, it seems to rapidly indicate the relative solution state of the solute.

The nature of some of the dyeing reactions may possibly be indicated by the study of surface concentration phenomena of dyes in the neighborhood of inorganic substances like silica, especially in determining the nature of the action of assistants in the dye bath, and whether this be due to alteration in the solution state or to some action on the fibre substance itself.

For instance, in the case of the addition of sodium chloride to the dye solution of "cotton" dyes, which both increases in the deposition of dye within the fibre area and also on the surface of silica, the indication is

[5] Dreaper and Wilson, J. S. D. & C., 22, 274, 1906, and J. S. C. I., 26, 667, 1907.

[6] Dreaper, J. S. D. & C., 1907, p. 188, and Dreaper and Davis, International Congress of Chemistry, 1909.

that some alteration in the solution state of the dye in which the salt disturbs the equilibrium—

$$\text{dye} + \text{solution} \rightleftharpoons \text{dye} + \text{fibre (or silica)}$$

by its tendency to "salt out" the dye, is the primary cause of the increased action, the solution then dyeing as a more concentrated one under normal conditions.

Reactions Involved in the "One Bath" Method of Dyeing.—Logwood and iron salts produce black dyes which are much used in silk dyeing. Alternate applications of solutions of these materials to the fibre produce black lakes of great intensity within the fibre area. If these solutions are mixed the same black color is produced but it is not possible to dye silk with this lake when suspended in solution in this manner, owing to the high state of aggregation of the lake particles. An addition of oxalic acid to this suspension in increasing proportion gradually dissolves this lake, the color of the solution passing from black to brown and then to gold in color as the action proceeds. The exact nature of this reaction is obscure, but the point for consideration is that, whether actual decomposition takes place or not, silk will dye readily out of this solution to a black shade, an equilibrium being established where the black lake is thrown out of solution and deposited within the fibre area and at the same time remains in the brown condition in the dye solution. In the presence of excess of oxalic acid, the solution is golden, and the silk dyes a deep brown shade, which turns black on washing with water. The nature of this reaction has been discussed elsewhere,[7] but it is evident that a reversal of this solution process (of whatever nature it be) is brought about in the fibre area. I have not yet been able to determine whether this action is due to surface concentration effects or to some more direct attraction, but experiments in hand will probably settle this point. In the presence of a greater excess of free oxalic acid the black lake is not deposited in the fibre area, but is then present within the fibre area in the dark brown condition. Partial neutralization of the oxalic acid shows that this reaction is a reversible one.

Condition of Fibre Substance During Dyeing.—It has been more or less recognized that hydration of the fibre substance may precede and modify the actual dyeing operation. It was thought that an investigation into the conditions under which organic coagula are formed might possibly throw some light on this subject.[8] It was observed, for instance, that although gallic acid had not the power to precipitate gelatine from aqueous solution, yet if this substance was precipitated by tannic acid in the presence of gallic acid a large proportion of the latter was carried down or formed part of the coagulum in a definite and quantitative manner. If the addition of gallic acid was made after the precipitation of the tannic-gelatine coagulum, the same proportion of gallic acid was absorbed. The equilibrium established between the gallic acid in solution and gallic acid in coagulum was a constant under these varying conditions. Also the physical properties of the tannic acid gelatine coagulum were modified.

It may possibly be argued from this that the actual state of solution or pseudo-solution of one of the reacting substances is a determining factor. This was more fully brought out when albumin was used in the place of gelatine, and the albumin simply coagulated by the action of heat. Here again there was a direct and very definite absorption of the gallic acid by the less soluble albumin. We were able to show also that in very concentrated solution gallic acid will even form this coagulum with albumin without any external aid and at ordinary temperatures. When it is remembered that the animal fires are slowly disintegrated even to a state of pseudo-solution by the continued action of aqeous solutions, as dyers sometimes learn to their cost, and that they are readily soluble in concentrated solutions of acids or alkalis, which substances are generally present in dyeing or scouring operations, it may be argued, I think, that a solution state of the fibre substance may be induced which may facilitate or govern the reactions on some such lines as those indicated in the formation of the above coagula, and so produce the color changes which are conveniently classed in industry under the term "dyeing." An extended set of experiments will be undertaken with these hydrolysed products to investigate this point. Investigation on these lines will, however, be complicated by the varying disintegration of the fibre substance under hydrolysis and the want of a method to determine the same.

A similar action has been recorded by O. Weber.[9] Although a solution of albumin is not coagulated by eosine G.G.F., yet if the temperature of the solution be taken up to 80° C, the coagulated albumin absorbs the eosine with avidity.

The modified reactions of the dyes towards mercerized cotton, as noticed by several observers and which I have discussed elsewhere,[10] is also a case in point.

General Conclusions.—These results when taken collectively sufficiently indicate the complicated nature of the action of dyeing. The different conditions under which the dyes are present on both the freshly dyed and the dried fibre, when dyeing takes place at different temperatures, is indicated by the varying resistance of the dye to the action of solvents. This has been confirmed in different ways, and has been shown to extend to the resistance to the action of acids in the case of the "indicator" series of dyes when they are present on the fibre.

In the latter case the general resistance against the color changes with acids is also evidence that there is some definite relation between the dyes and fibre colloids, especially when it is observed that sulphuric acid may be present in the fibre, and yet not react with

[7] Dreaper, J. S. C. I., 1905, p. 225.
[8] Dreaper and Wilson, Proc. Chem. Soc., 22, 70, and J. S. C. I., 1906, p. 515.
[9] J. S. C. I., 13, 1151.
[10] Dreaper, Chem. News, 90, 179.

such a sensitive reagent as methyl orange, nor prevent it dyeing the fibre orange out of a red (acid) solution. It must be remembered that the free color acid is orange, and not red.

The abnormal result obtained on raising the temperature of the acid dye bath, and the indication that under these conditions the fibre substance shows an increased affinity for the dye as measured by the above color reactions with acids, is equally definite. This phenomenon seems to correspond in some way with the general dyeing action observed in practice, where the dye is more readily absorbed by the fibres at a higher temperature. These experiments also indicate that this is not due to a greater penetration of the dye into the fibre substance at the higher dyeing temperature, but to some closer and more definite relation between the dye and fibre substances respectively, and that the action with acids is a reversible one.

The nature of this, as indicated by these experiments, and when judged by ordinary standards, is abnormal, but some such variations may also occur in the case of ordinary colloidal reactions. This point will be followed up and investigated.

The changes brought about when the "ingrain" or developed dyes are produced in the fibre itself also indicate some variation from the normal dyeing reactions, especially when the abnormal reaction of some developers is considered. It is interesting to note in passing that it has been observed by Cross, Bevan and Green that the diazotised primuline produced in the fibre is, by comparison, exceedingly sensitive to the action of light.

The fact that the animal fibres themselves will react with nitrous acid and amines, or phenols, in a similar way to primuline itself, may indicate an active condition of these fibres which must be considered in relation to the general reactions between dyes and animal fibres; but it is equally true that the vegetable fibres (which do not react in this way) give equally "fast" results with the ingrain dyes, as measured by their subsequent resistance to the action of such reagents as soap or alkaline solution.

Interesting results will probably be obtained from the further consideration of this matter in detail. The delicate color reactions involved render the study of the reactions of such bodies a comparatively easy one. Also the colloidal nature of at least one of the reacting substances at the time of dyeing adds an additional interest from the point of view of the reactions of these bodies and their solution state.

As a result of observations of this nature I was led in 1905[11] to suggest that molecular migration from one dye aggregate to another might come into play, and establish an equilibrium of size or something approaching it in pseudo-solutions, and incidentally account for some obscure reactions in dyeing by the "one bath" method, when the mordant and dye are actually present in the same dye solution. This suggestion was founded, by analogy, on the Poisson-Maxwell theory of atomic migration. Some action of this nature might also explain such phenomena as the "ripening" of solutions of cellulose and nitrocellulose and possibly the slow diffusion of colloids.

It is obvious that if dye aggregates were formed within the fibre substance by the entrance of single molecules (or smaller aggregates) of the dye, many of the observed reactions might be accounted for.[12] At that time I suggested that the possible action of dyeing might be summarized in the following terms:

(1) A solution state of the dye within certain limits of aggregation as determined by the laws of solution.

(2) A fibre state corresponding to this state of aggregation and of a permeable nature.

(3) Localization of the dye within the fibre area by surface concentration phenomena.

(4) Localization of salts, acids, etc. (assistants), within the fibre area from the same cause.

(5) The direct entrance of dye aggregates by molecular migration, with subsequent reformation of aggregates within the fibre area, according to the above suggested variation in the state of aggregation.

(6) De-solution, due to concentration effects ("salting out," etc.), or secondary attraction, between the fibre substance and the dyes.

(7) Primary or chemical action, which may play some part at this stage, and may even in some cases take the place of, or cause, de-solution phenomena.

(8) De-solution effects in the case of basic dyes, which may lead to alteration in constitution, and the production of very basic salts in a state of high molecular aggregation (insoluble) within the fibre area.

The question of surface concentration does not seem to be fully appreciated yet in its relation to dyeing, but the tubular nature of the cotton fibre, and the statement made that a cross-section of this fibre indicates that the dye is chiefly present in the center of this fibre,[13] shows that the conditions for such concentration may be present. It will be remembered that even potassium permanganate may be "filtered" from its solution by a passage through finely divided silica.[14] The passage of a solution of a salt through capillary tubes, where the salt collects at the walls, due to the difference in surface tension of salt solutions as compared with that of pure water, is also a case in point,[15] it being an observed fact that if filter paper is dipped into such a solution the solution in the filter paper is stronger than the rest owing to the diminishing value of the surface tension at the surface of contact between the salt solution and a solid body. The subject has been considered by J. J. Thompson.[16] If a colloid such as albumin takes the place of the salt the capillary tube may be completely choked through the actual de-solution of this substance.

[11] J. S. D. & C., 1905, p. 136.

[12] Dreaper, J. S. D. & C., 1905, 21, 136.
[13] Gnehm and Rotheli, Zeit. f. angew. Chem., 1898, pp. 482-488.
[14] Application of Dynamics to Physics and Chemistry. J. J. Thompson, p. 192.
[15] Ibid.
[16] Ibid.

Knecht and Batey have recently proved by the electrical conductivity method that a series of dyes give true solutions with water.[17] This work confirms similar results obtained by Pelet-Jolivet and Wild.[18]

W. M. Bayliss has also shown that Congo red has an osmotic pressure equal to that expected, if it were in true solution in single molecules. This condition is, however, only to be obtained in the complete absence of electrolytes, which never exist in practical dyeing. Even the CO_2 present in ordinary distilled water causes a marked fall in pressure.[19]

At the same time it must be remembered that dyes generally "salt out" of their solutions, and also salts are generally present in dye solutions. So that dyestuffs which, while being capable of "salting out," exhibit in dilute solutions some of the properties of true electrolytes, may still deposit on the surface of fibres by this action of surface concentration as I have indicated. If both the dye and salts are concentrated beyond the critical de-solution point of the former at the fibre surface such an action must necessarily follow. So that the fact that certain dyes behave in dilute aqueous solution as electrolytes (as might possibly be expected with salts of sulphonic acids) must not be taken as evidence that the dyeing action is one in which some of the other properties of colloids, and these dyes, play no part. Then, again, is there any direct evidence that if such electrolytes are dissociated in solution, the dissociated aggregates are not themselves in a state of association with the solvent, and therefore possibly in some state equivalent to pseudo-solution and therefore act in an equivalent way to ordinary colloids? Such a state might be assumed if one accepts the Lowry ionic hydrate hypothesis. These units might also be subject to surface concentration effects, and so produce certain specific effects in this direction.

When the position is reviewed, and the work of different investigators considered in detail, the subject is certainly a complex one. I have dealt with the matter generally elsewhere,[20] and have confined myself on the present occasion to the discussion of the series of reactions mentioned.

That certain known reactions between colloids in a state of pseudo-solution may account for dyeing reactions must be conceded, and several investigations have been undertaken with the object of proving this to be the case. If the reactions which "fix" the dyes are of this nature, a general investigation of the conditions governing the phenomena, even if they be of the nature of such commercial operations as dyeing or tanning, must throw further light on this subject generally and be worthy of special attention. In conclusion, the consideration of the above experimental data, when taken collectively, indicates that the dye is not only fixed on the fibres by reactions, which are obscure, but that this affinity may vary in intensity with the temperature of the dye bath, or may be otherwise modified by the method of application, as in the case of the ingrain colors.

The Solution State of Dyes.—The consideration of these results and others led to the suggestion[21] that the act of solution might possibly be represented by the following formula:

$$(OH_2)_xH - Cl(OH_2)_x,$$

the primary bond—being reduced by the secondary attraction $_x$ but never entirely extinguished, as since suggested by Dr. Lowry,[22] and as represented diagrammatically in the following way—

$$(OH_2)_yH, \qquad Cl(OH_2)_x,$$

where the ionic hydrates actually exist as definite and independent units. The presence of any free ions being due in the former case to atomic migration by direct interchange of the H and Cl atoms, the increasing tendency to migrate being due to the increasingly unstable condition set up by the reduction in value of the primary attraction or bond as determined by the suggested conditions. Such a system need not interfere with the simultaneous formation of hydrates, which are known to be present in some solution systems.

A preliminary report of the U. S. Census Bureau gives the following comparative summary of the operations in 1909 of the 116 hardwood distillation plants using 1,150,000 cords beech, birch, maple, etc., and the 31 softwood distillation plants using 116,000 cords longleaf pine, etc.:

	Hard wood.		Soft wood.	
Product.	Amount.	Value.	Amount.	Value.
Charcoal, bushels	53,075,000	$3,299,000	2,403,000	$210,000
Crude alcohol, gallons	8,468,000	2,082,000	.....	.....
Gray acetate, pounds	148,769,000	2,203,000	.....	.....
Brown acetate, pounds	2,157,000	22,000	.....	.....
Iron acetate, gallons	303,000	28,000	.....	.....
Oil, gallons	38,000	3,000	323,000	770,000
Tar, gallons	.....	.....	1,365,000	105,000
Turpentine, gallons	.....	.....	683,000	243,000
All others	.....	5,000	.....	59,000
Total value	.....	7,642,000	.....	687,000

Since the discovery of Chili gold has been mined valued at $222,923,005, silver at $311,093,058, copper at $658,575,153, and nitrate at $1,122,874,274. The 20,632 mineral claims cover 522,336 acres, of which 10,821 are copper, 3,893 gold, 904 silver, 86 gold and silver, 530 gold and copper, 173 iron, 99 manganese, 32 aluminum, 1 antimony, 1 nickel, 4 mica, 338 sulphur, 1,385 nitrate, 687 salts of potash, 399 salt, 4 diamond, 33 china clay, and 40 coal.

Some Japanese in Tieling, Manchuria, have started the manufacture of pulp from millet, which grows in abundance in Manchuria. They have concluded negotiations with the Japanese authorities for a lease of land covering 1,000,000 tsubo for the cultivation of millet, and it is stated that at present 250,000 tsubo have been planted with millet by way of a trial (1,210 tsubo = 1 acre).

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[17] J. S. D. & C., 1909, p. 194.
[18] Comptes Rendus, October 19, 1908.
[19] Proc. Royal Society, B. 81, 269 (1909).
[20] Chemistry and Physics of Dyeing, Churchill, 1906.
[21] Dreaper, J. S. C. I., 1905, p. 226, and Chem. News, 1905, 92, 229.
[22] Faraday Proc., 1, 197 (1905).

THE PLANT.

FLUXES AS APPLIED TO THE BRASS FOUNDRY.*

By ERWIN S. SPERRY.

In the early days of brass founding two things were guarded jealously: The mixtures and the fluxes. At that time it was not an uncommon occurrence to hear one say, when speaking of a new proprietor of a brass foundry: "He will get along all right. His father left him all his formulas for mixtures and fluxes." It seemed to be taken for granted that even capital itself was subsidiary to those heirlooms. Soon the chemist began to make serious inroads into the mixtures and their secrecy faded away gradually but surely. The mystery of the fluxes was more difficult to eliminate as, unlike the castings themselves, they did not go beyond the foundry. They could not be analyzed without obtaining at least a small quantity, and this was difficult to do, as the brass founder carefully guarded them and the materials from which they were made. In the course of time, however, the secret fluxes went the way of the brass mixtures, so that by the process of evolution "secrets" finally became general technical knowledge. Few brass founders are now found who claim to have anything original or remarkable in the flux line.

When fluxes are mentioned, it is frequently asked: What is their advantage, and are they actually necessary? To answer this question, I will say that I believe the flux question is greatly overdone and likewise imperfectly understood. It was only a short time ago that I discovered a brass founder using lime in making an 88-10-2 mixture from new metals. He said "somebody" had told him that it was good for bronze. Although cheap substance that it is, he was wasting his lime, as it remained on the metal like so much dirt and had no more effect than sand. In another instance I found that a brass ingot maker used a couple of handfuls of a mixture of common salt and borax on the top of a pot of yellow brass after it had been skimmed and immediately before pouring. The mixture was thrown on and then at once skimmed off without waiting for the borax even to stop swelling. He, too, would have been equally as well off without the flux. Another, but diametrically opposite case, was a brass founder who attempted to melt his emery grindings in a crucible without a flux and obtained about a pint of metal and half a bushel of dross. In this case a flux was needed.

It hardly will be advisable to go into a detailed enumeration of all the fluxes known to mankind and that can be used in brass melting, as it would be of little value. Many substances once used for this purpose have now become obsolete and many others have proven to be valueless. It seems preferable, therefore, to give a description of those fluxes that the test of time has proved valuable and the manner in which they should be used.

Flux for Aluminum.—For years those who melted aluminum used no fluxes at all on it, not even charcoal, as it was soon found, that this material did more harm than good. On account of the lightness of aluminum, charcoal does not readily free itself and is apt to become entangled in the metal and produce small, black spots in the casting. It is within the past few years that a flux has become used.

For aluminum, the flux that is most extensively used, and which has proved to be so valuable is *chloride of zinc.* It seems to react with the aluminum, forming chloride of aluminum and metallic zinc which alloys with the aluminum. When this takes place the dross is changed to a fine, granular condition which is readily skimmed off. When aluminum is melted, the surface is covered with a rather thick mass, but the chloride of zinc will change it to a perfectly clear one closely resembling in appearance molten tin or lead. It is needless to say that such clean metal gives better castings.

The method of using chloride of zinc as a flux in melting aluminum is simple. Small pieces are thrown on the surface after the melting has been completed. Enough has been added when the surface is clear. A very small amount usually suffices and for 50 lbs. of aluminum a piece of the size of a walnut is generally enough. The metal is stirred immediately after the addition and then skimmed. Those who have not used chloride of zinc should try it, as it is an excellent material.

Flux for Nickel.—The flux used by makers of nickel anodes has proved to be a good one. It was first used by A. M. Hill of New Haven, Conn., one of the first in the United States to make nickel anodes and the inventor of the well-known "Hill-Barrel" for grinding brass furnace ashes. Mr. Hill has retired from the anode business, but for many years he used this flux with the best results. It is not only good but cheap. It is composed of the following:

Lime ..... 3 parts
Fluor-spar ..... 1 part

The manner of making it is to take the lime and slake it as though mortar were to be made. Then

*Paper read before the American Brass Founders' Association.

stir in the fluor-spar and allow it to become solid. It is then broken up into small pieces for use.

While fluor-spar alone is a good flux, it becomes very fluid when melted and rapidly attacks a crucible. I have seen a new plumbago crucible ruined in one heat when fluor-spar was used alone. It seemed to soak in and dissolve out the clay from the crucible mixture and leave nothing but the graphite. The crucible collapsed like an egg shell when grasped with the tongs. The use of the lime with the fluor-spar is to increase the melting point so that it will not so readily attack the crucible. The proportions previously mentioned have been found satisfactory for nickel. Less lime will render it more fusible.

This flux has been found particularly serviceable in melting old anodes as it dissolves any earthy matter that may be on them. It is used for both new and old material, however, and may be called the standard flux for nickel. The proportions used are about a pint or a good handful for a new nickel, and twice this quantity for old material.

It must not be imagined, because the fluor-spar is toned down with lime, that the flux will not act on the crucible, for it certainly will. The crucibles last only five or six heats. In this connection it should be borne in mind that all fluxes act on the crucible to a greater or less extent, otherwise they would not be of value as a flux.

Flux for Copper.—There probably have been more fluxes proposed or used for copper than for any other metal or its alloys. The fact that copper cannot be melted alone and obtain sound castings from it has brought about this fact. Practically every known chemical has been tried. In the selection of a flux for copper, it should be known whether pure copper castings are to be made, or whether it is to be alloyed to make brass or bronze.

To make sound copper castings with a flux alone, and without the use of "physic" like silicon-copper, magnesium or similar materials (which strictly speaking are not fluxes) is a difficult matter. For this purpose I have found that yellow prussiate of potassium (potassium ferrocyanide) is excellent. With it sound copper castings can be made, but I do not advise it as far better results may be obtained by the usual deoxidizing agents, such as silicon-copper, magnesium, phosphorus, etc.

In melting copper for producing brass or bronze, the question is different from the preceding one. For this purpose there is nothing better than *common salt*. Its value lies in the fact that it possesses the property of reducing any oxide of copper which may form during the melting. It has been used for years in the brass industry and the memory of the "oldest inhabitant" fails to indicate the date of its inception.

Common salt is so efficacious in reducing oxide of copper that as far back as 1882, R. Monger in the *Chemical News* proposed it as a means for determining the quantity of oxide that copper contains. His method was to melt salt in a clay crucible and then drop in the weighed sample of copper. After allowing it to remain for a short time, the crucible was cooled and broken when the button of pure copper was obtained. The difference in weight gave the amount of oxygen (or its equivalent of oxide of copper). Some very satisfactory results were cited.

In melting the copper for making brass or bronze, about a handful of salt is used and is preferably put in after it has begun to melt. If introduced with the copper, it melts before it and is apt to volatilize and waste. The action on the crucible is also greater. Too much salt produces a liquid that is apt to penetrate the crucible like fluor-spar, although not as violently or as rapidly. The amount of salt previously given is used for a pot of metal holding about 150 lbs. The quantity need not be exact, as a variation either way does no harm as long as a sufficient quantity is used to do the work.

The theory of the action of the common salt seems to be that, at the temperature of the molten copper, it breaks up or dissociates into metallic sodium and chlorine gas. The latter escapes and the sodium performs the work in deoxidizing.

Flux for Brass.—The flux almost universally and exclusively employed in brass melting is *common salt*. As previously mentioned, its action is to reduce the oxide of copper formed in melting the copper previous to the addition of the spelter. The brass rolling mills in the Naugatuck Valley, Connecticut, and elsewhere as well, all use it, and one large company uses approximately half a ton a day. It is the universal and only flux used in making brass for rolling. For years it has been employed for this purpose and in my own remembrance always has been. It seems to give all that is desired and has the distinct advantage of being cheap. Any kind of salt will answer and a pure material is unnecessary.

The quantity used is about a handful to the crucible. One concern uses one handful, while another believes that double this quantity should be used. A good-sized handful, however, seems to be sufficient. It is added after the copper begins to melt as this appears to be the best time to introduce it. When the right conditions have been produced, there will be a little slag on the top of the brass when it is skimmed.

It is worthy of note that, although every brass rolling mill uses salt in brass melting, few brass founders who make sand castings employ it. Many of them never have heard of it and others seem to think it is a waste of time. I advocate its use under all conditions and as it is theoretically correct, has been found by actual practice to improve the quality of the brass, and is so cheap that the cost of the brass is not appreciably increased, it seems to me that every brass founder should use it, whether he makes new metal or melts scrap, as the character of his castings will be improved.

Flux for Bronze and Composition.—What has been said about the use of *common salt* in melting yellow brass, applies equally well to composition or bronze.

and it is used in identically the same manner and in the same quantities. It makes no difference whether phosphorus or other deoxidizing agents are employed, the salt is used just the same.

Flux for German Silver.—German silver is such a refractory material in the rolling mill that much time and thought have been given the subject of a suitable flux for it. It is a singular fact that the bulk of the German silver manufactured in the United States is made by two concerns. One uses a flux in making it, while the other uses none. In justice to the concern which uses no flux at all, I will say that their German silver has a little better reputation and they have the more particular trade. I cite these examples simply to indicate that fluxes do not constitute the "secret" of making German silver, by any means.

The use of the flux by the other concern dates back to 1869 when Frederic Wilcox, a brass caster, who was engaged in making German silver, had trouble with black, minute spots in his metal. Tradition states that he gave the matter much thought and finally believed it was caused by carbon in the metal. More "thought" indicated to him that the only method of removing it was to use a nitrate of some kind which would evolve oxygen and oxidize the carbon. Nitrate of soda, therefore, was used and upon its use in the German silver he obtained a patent (U. S. Patent No. 96,524, Nov. 2, 1869). As this material was found to work better with black oxide of manganese, the two afterwards were used together and now constitute the flux of the aforesaid concern.

Personally, I doubt whether this flux has much value, and the fact that it is possible to make good German silver without it would seem to indicate it. I feel quite sure that there is no oxidation of carbon, as nitrate of soda, when allowed to melt on copper, will not oxidize it; but instead will actually render it sounder. It is also a singular fact, which I have already demonstrated in practice, that a mixture of nitrate of soda or the nitrate of potash (nitre), mixed with black oxide of manganese and used as a flux on copper, will actually introduce metallic manganese into the copper, showing that there is a reducing action. This explains, I believe, the reason for the action of the flux. A slight amount of manganese is introduced. This is also borne out by the fact that within the last few years, metallic manganese has come into use as a deoxidizing agent for German silver and similar nickel alloys. Its use is preferable to introducing manganese through the agency of a flux as the results are then positive and certain and pre-determined amounts of manganese always can be added. Its use has been attended with excellent results and it seems to be the natural deoxidizing agent for nickel and nickel alloys.

In making German silver, common salt is used in the same manner and with the same results as those obtained in brass and bronze.

Fluxes for Washings, Grindings, Etc.—In the melting of washings from the reclaiming of brass foundry ashes, a flux must be used in the majority of instances, unless they have been washed very clean, and this is rarely done. Even with clean washings a flux is advisable. The same rule applies to grindings, skimmings and similar waste materials. Unless a flux is used when they are melted, a union of the particles of metal is prevented by the presence of so much foreign matter, and instead of fluid metal there usually is obtained a small quantity in the bottom of the crucible and a large mass of pasty material fritted together. When a flux is used the foreign matter is dissolved and clean metal is left.

For use in melting brass, bronze or composition washings, grindings, skimmings and similar material, I have found nothing better than *plaster of Paris.* It is a cheap and excellent flux for this purpose. How far back it was employed for this purpose I cannot say, but it was first called to my attention in 1890 by the late C. S. Moore.

With due respect to the late C. S. Moore, I believe he can really be called the father of the present scrap metal industry in the United States, as he was responsible for many innovations (like the "transmutation" of yellow washings into red), and I firmly believe he was the first to use plaster of Paris as a flux. He informed me to this effect and I have no reason to doubt his word.

The value of plaster of Paris as a flux in melting washings, grindings and similar material is that it possesses the property of dissolving what foreign matter may be present in the shape of sand, slag or oxide, and it has practically no action on the crucible. In addition it is quite cheap. On account of the fact that it has no action on the crucible, any desired quantity can be used. It melts readily and forms a thin slag.

To melt washings or grindings with plaster of Paris, mix about 5 lbs. of it with the washings when they are placed in the crucible. Then melt in the usual manner. If the slag at the conclusion of the melt is not sufficiently fluid, more should be added. When the metal is completely melted pour the entire contents of the crucible into ingot molds. *Do not attempt to skim it.* The slag will run into the molds with the metal and rise to the top. Allow the mass to cool and then dump the ingot molds. The slag of plaster of Paris can be readily detached by a blow from a hammer, or it usually will fall off under normal conditions. If desired, it may be used again. It will be found a very satisfactory flux for this purpose.

Plaster of Paris is calcium sulphate, and when used as a flux, the action seems to be one of simple solution: The molten plaster dissolves the foreign matter as sugar is dissolved by water.

When coal is present in washings, as it usually is, there is a slight reduction of the sulphate to sulphide and there will be an odor of sulphur during the melting. This seems to do no harm, and I have never been able to find that it injures the metal. In fact, it appears to act in an opposite manner, and any iron that

may be present is changed to sulphide and enters the slag. I have always advocated the use of plaster of Paris in melting scrap materials containing iron, and have invariably found it to be followed by good results.

Necessity of Charcoal.—I have made no previous mention of the use of charcoal for the reason that it is not properly a flux, although it takes the place of one. I can say without hesitation that charcoal should be used as a covering in melting all the metals previously enumerated except aluminum. Its value lies in the fact that in burning it supplies a reducing atmosphere and thus prevents the oxidation of the molten metal. At the same time it covers the metals and prevents the products of combustion from coming in contact with it. It is free from sulphur which renders it the ideal material for this purpose. It should be coarsely granulated and not powdered so as to allow its covering the metal completely without danger of immediate combustion. Fine coke or coal, although frequently used, is much inferior to charcoal as it contains more or less sulphur which injures fine grades of metal.

According to a preliminary report in 1909 issued by the U. S. Census Bureau, there was consumed in the United States during the calendar year 1909 in the industry of wood distillation, 1,265,000 cords of wood, as against 978,000 cords in 1908 and 1,282,000 cords in 1907. The average cost per cord reported for the 1909 consumption was $3.21, which was an increase of 23 cts., or 8 per cent over that reported for 1908, and of 6 cts., or 2 per cent, over that for 1907. While a substantial increase is noted in that branch of the industry using yellow pine, fir, and other soft woods as material, the revival of activity was more marked in hardwood distillation, due undoubtedly to the material advance in the average value per gallon of wood alcohol over the two preceding years. While the average value per unit has varied little for most of the products of hardwood distillation during the past three or four years, for alcohol it has fluctuated over a wide range, following the passage of the so-called denatured alcohol law, which became effective Jan. 1, 1907. The average value per gallon reported for crude alcohol manufactured during the calendar year 1906 was 34 cts. In 1907 it dropped to an average of 15 cts., increased to 17 cts. during 1908, and reached an average of 24 cts. in 1909. The use of sawdust and other mill waste as material in 1909 was substantially greater than in any preceding year and the indications are that the industry will develop largely in future in the direction of utilizing this class of material.

During the first six months of 1910, 406,000 tons of coal were mined in Chili, of which 241,552 tons were consumed by shipping interests.

CELLULOSE.*

By CARL G. SCHWALBE.

The first attempts to substitute other prime materials for rags, old linen, or cotton waste for the manufacture of paper date from the middle of the eighteenth century. Even at this time these prime materials were getting scarce. Christian Schaeffer of Ratisbon, attempted in 1765 to make paper from wasp nests, turf, straw, hay, the twigs of hops, from brush broom, and even from wood, but his efforts brought no results except the contempt and jeers of his contemporaries; the time had not yet come to realize this idea, and moreover the scarcity of rags had not yet become pressing. But when the development of daily newspapers, and the necessity of satisfying the demands arising from the extension of popular instruction had made these ideas acceptable, the search for substitutes for rags became permissible; thus it was that towards the middle of the nineteenth century, the attempts of the weaver Keller to de-fiber wood so as to obtain a pulp, to replace the pulp from rags, were favorably considered. There should be remembered, too, the attempts made by Melliers, among others, who frequently tried to treat straw so as to extract from it a pulp which could be used industrially. Cellulose treated with soda soon followed the mechanical wood pulp and straw pulp.

In fact, the process of treating wood, as well as straw, with caustic alkalies or alkaline earths became a success. Moreover, very soon after this alkali process had been brought from America to Europe by Houghton, it found a competitor in the chalk process, or in the sulphurous acid of bisulphite process. The names of Tilghman and of Ekman are connected with the first experiments made in Germany to use calcium sulphite or magnesium sulphite for this treatment. At this time, this process, which had been kept secret fell into oblivion. The energy and determination of Mitscherlich and his licensees developed a practical industrial process, which, concurrently with the analagous process of Rittner-Kellner, soon brought the new industry to an extraordinary stage of development in the short space of 25 to 30 years.

The production of cellulose amounted to 1,600,000 tons, of the value of $80,000,000; the proportion of cellulose treated with caustic soda was very small. This was due to the fact, that for various reasons, still disputed, the bisulphite process of treating wood seemed superior to the soda process. However, in spite of the considerable extension of this process, in spite of the great progress it has made as to the yield, both in quantity and quality of the product, hence the certainty of the methods of manufacture, still the cellulose industry depends almost entirely on empiricism. The chemical composition of the raw material, wood, and of its manufactured product, cellulose, is still almost completely unknown to us.

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The cellulose industry and its allied industries of cotton, gun cotton, and artificial silk are thus in an analogous condition to some other industries, for example, the leather industry; from this point of view they are in a totally different condition to the great industry of inorganic chemical products or of coloring matters. In the case of these latter industries, the exact chemical knowledge of their raw materials and of their intermediary products has allowed them to advance very methodically and in well-chosen paths; and this has made their recognized brilliant development possible.

May I be permitted here to make a rapid sketch of what the cellulose industry and its allied industries are; to point out what problems are not yet solved, the solution of which is demanded as much by the chemist as by the technical man; and to express how necessary it is to base these industries upon more solid chemical knowledge than they actually possess at present?

To begin with, let us consider the manufacture of mechanical wood pulp, of which 500,000 tons, worth $12,500,000, are produced annually in Germany. At first sight this manufacture does not seem chemical. In fact, the decorticated wood is crushed flat between millstones and under a stream of water, either perpendicularly to the course of the fiber or with the fiber; the fibrous pulp thus obtained is refined, freed from splinters of wood, and then worked in different ways so as to yield various products, such as strawboard, but chiefly the substance to which a small quantity of cellulose is added to make the paper for the daily journals.

If one of the stages which this process has lately reached is studied, that known as the method of defibring by the hot process, which came from America, we are plunged at once in a chemical problem. In this method, as a preliminary treatment, recourse is had simultaneously to boiling water and a very high pressure, working at as low a temperature as possible.

Boiling with water under these conditions, when it is for a short time only, appears to dissolve a certain part of the wood and to yield a very large quantity of very long fibers, with a small residue of broken fibers. The effect naturally goes much farther if the water is allowed to act for too long a time and under greater pressure. To obtain very resistant fibers, certain constituents of the wood are dissociated, and then the custom is to recover them by the production of the brown mechanical pulp. This pulp is specially used to make a very strong leather board. Unfortunately, carbonization begins during this process. According as the temperature and pressure (4 atmospheres on the average) are more or less high, a correspondingly more or less marked brown color is produced. Is this due to the formation of humus? As vanillin and acetic, formic, and oxalic acids are found in the residual lye, it is not improbable that oxidation is set up.

It has been attempted to remove this extremely troublesome brown color by bleaching, but in vain.

However, there appears to be some hope of success in preventing the production of this brown color, that is of preventing the oxidizing agents from acting; to effect this, either the air in the autoclave (digester) and in the pores of the wood is removed by producing a vacuum in the autoclave; or, before boiling, the wood is impregnated with a solution of a reducing agent, such as sodium sulphide. Besides this question of discoloration, other technical problems present themselves; in any case there is the utilization of the residual lye, which may contain as much as 10 per cent of the weight of the treated wood. The solution of this problem opens up many scientific questions: From what portion of the ligneous substance are the organic acids derived? Is the process an hydrolysis? Above all, what is wood? And if in the course of our researches we take up those which refer not only to the mechanical pulp of brown wood, but also those which concern the white mechanical pulp, how is it that the paper made from mechanical wood pulp turns brown so quickly? And how shall we determine the amount of wood in a mechanical pulp when it is mixed with other fibrous substances? Quite recently Messrs. Cross and Bevan have answered this question by an approximate solution. A solution of phloroglucin in hydrochloric acid gives a beautiful purple color to wood, which has long been used for the colorometric determination of the quantity in mechanical wood pulp, in fixed proportions by weight. If wood pulp, or a substance containing wood pulp, is placed in a solution of phloroglucin of known strength of the solution is determined, the quantity of phloroglucin consumed allows a conclusion to be drawn as to the amount of wood in the pulp.

The absorption of an inconsiderable quantity (6 to 7 per cent) of phloroglucin by lignin, led Cross and Bevan to recognize in this fact a proof that only the ketone compounds and not the aldehyde compounds act in this way, for the aldehyde compounds will have been oxidized by the chlorine and could not give this reaction. This assumption, formulated by the English scientists, on the presence of compounds reacting in the lignin, leads us to recognize quickly the hypotheses which have been made on the subject of lignin. Scientists are agreed in admitting that there must be an aromatic nucleus in lignin. Czapek, by heating sawdust (wood shavings) in water under pressure, obtained a substance which he called hadromal, which was recognized later, thanks to the work of Graefe, as being a mixture of vanillin, methyl furfurol, and pyrocatechin. Graefe concluded that from the quantity of methoxy compounds in the wood the quantity of vanillin could be deduced, and further that this must be the chief constituent of lignin. It is not necessary, however, that all the methylic compounds should produce the vanillic nucleus, as Fromher has shown. Moreover, it appears very probable, according to the recent researches of Klason, that lignin is composed of coniferyl alcohol (a compound closely related to vanillin) and of a derivative of this alcohol, oxy-

coniferyl alcohol, for four similar nuclei have been formed by separating the water.

This constitution would be allied to that of the carbohydrates and should be of the same character as a glucoside. In fact, when water acts upon wood, a solution is obtained containing 10 to 12 per cent of a wood gum, which is a carbohydrate, from which proportion the content of lignin is deduced as 26 to 30 per cent. It is remarkable that invariably only 1.4 per cent of carbohydrate is found in the residual lyes of the bisulphite process; it must be admitted then that the pressure, the rise in temperature, and the chemical agents have a destructive action. Let us remark, in passing, that it is possible after that to answer the question so many times asked, whether it is not possible to manufacture vanillin by utilizing either the residual lyes derived from the hot process of making wood pulp or the lyes from the bisulphite process. At the very low price of $4.55 per pound, which is the present price of vanillin, no one would be interested sufficiently to make the extraction. Besides, it must first be considered that the demand for vanillin is not so important now, and that if this question was solved, it would not solve the problem of utilizing not only the celloulose but also the lignin of wood.

These considerations have led us face to face with that problem of the cellulose industry which is the most difficult to solve and at the same time the most important. What will become in the future of these innumerable organic substances dissolved in water, when our rivers refuse to accept them; or what will remain, even of the business itself, when the laws protecting water courses, threatening even now, become active, and forbid us to throw the residual lyes into them in such large quantities as has been done up to the present time? The quantity of organic matter dissolved in water is nearly equal to the 564,000 tons of cellulose, and means must be found of destroying it.

Having given the outline of this discussion, it is impossible to detail the numerous processes which have been suggested for the utilization of the residual lyes. However, that attention may be called to the most recent of the processes in this direction, it will suffice to mention the one now on trial at Langen in Hesse. By heating the residual lye from the chemical wood pulp of the bisulphite process in the presence of acids and, when required, applying pressure and adding formaldehyde, a tough and plastic body precipitates. The question now is to ascertain if this product really has such desirable properties as will allow of its use in such a way as to assure a large demand for it. This product may be considered as cellulose pitch. This is the name given to the product obtained at Walsumam Niederrhein by evaporating the residual lyes nearly to dryness, and has proved to be an excelient agglutinant for the agglomeration of powdered minerals. The whole question lies in knowing if, in such a case, the cost of evaporation would not be too great, in which event the process is of no value from an economic point of view.

In the production of cellulose by soda, the residual lyes need not cause any uneasiness. These lyes are concentrated and then calcined to extract the alkali contained in them.

In this case the organic matter which the lyes contain partly furnishes the fuel necessary for their recovery. This process has one great drawback, which explains why it is not more frequently adopted; the treatment of these residual lyes sets free very noxious fumes, which, up to the present, cannot be avoided. This inconvenience and the small yield of cellulose are the reasons for the abandonment of this process in Germany. At this moment, laws are being prepared in Scandinavia, with a view to the total suppression of the noxious fumes from this manufacture, and thus the existence of the industry of making cellulose by the soda process is strongly menaced in those countries.

But the utilization or the suppression of the residual lyes are not the only important problems. Cellulose, whether obtained by boiling with alkalies or from an acid solution, must be bleached. This does not mean merely to destroy the very slight color of the chemical pulp of heated wood, but rather to carry out an operation, which is a true chemical attack accompanied by a great loss of weight (4 to 10 per cent in the case of bisulphite cellulose). There is no doubt that the discoloration would be much more intense and much more difficult to destroy in the case of caustic soda cellulose than it is with bisulphite cellulose. We do not know the nature of the color; besides this problem has remained unsolved in another industry, the elder sister of the cellulose industry, the manufacture of cotton, for the coloring matter which causes the discoloration of raw cotton is not clearly recognized; it is only known that it seems to act as a caustic, a destroyer. As it seems to us, instead of completing the treatment by bleaching, it should be asked if the bleaching cannot be done during the treatment? Experience has taught that if the treatment is pushed too far the quantity and quality of the product are influenced to a considerable degree. The treatment should be considered as a sort of hydrolysis, so that on continuing it too long, not only the lignin, but also the cellulose itself is attacked. Thus in the soda process, it must be admitted that after solution of the compound (analogous to an ether) which is formed by the cellulose and the lignin, the lignin is changed into lignic acid by the alkali, for Lange obtained not only cellulose, but also a certain quantity of lignic acid, by fusing wood and alkali together. The theories that have been suggested as to the reactions in the bisulphite process are very diverse; whether the acid radical of the sulphurous acid remains in the state of a double salt; or whether it reacts with the aldehyde compounds; or again whether it forms ethers or sulphonated acids. The last view is the one most accepted, thanks to the work of the Tollens laboratory, in fact the presence of a sulphonated acid combined with the process; and from this compound, though with great difficulty, by means of alkalies, a sulphonated acid has been sep-

arated at the same time as a lignic acid, apparently identical with that obtained from the soda process.

It seems to us that these considerations only concern lignin. But what can we say relatively about cellulose? Is there really a unique cellulose which is isolated when the boiling is not continued too long? Are there fixed quantities of a less stable cellulose which go into solution? It is certain that this is the case in the soda process of making cellulose; in fact the yield is 15 to 25 per cent less than that obtained in the bisulphite process, and the product even after bleaching does not always appear identical with cellulose from cotton; for among other distinctions it reacts with phenylhydraxine, and forms furfurol when distilled with hydrochloric acid. Are these reactions due to the existence of a mixture of several different celluloses, or are they due to a single cellulose, or again are they due merely to impurities, difficult to remove? What will remain when these impurities are eliminated? It is plain there is no lack of unsolved questions and that all of them, more or less, await their solution by work based on experiment. But that is not all. The different kinds of cellulose formed during the boiling show still more subtle differences and present an immense field for purely chemical research, for, up to the present time, the various kinds cannot be completely differentiated by their physical properties. There are certainly different kinds of cellulose pulp obtained, according as they are treated by slow boiling as in the Mitscherlich process, or by rapid boiling as in the Rittner-Kellner process.

Are all these different hydrates one and the same cellulose like that of cotton? These questions remain for the most part unanswered. Only one of the questions relating to the carbohydrates has as yet received a reply. It is now known, at least, that by excessive treatment of the bisulphite cellulose, a transparent substance is obtained looking like parchment externally, and quite comparable to vegetable parchment, which has been called pergamyn. But pergamyn is not a cellulose hydrate, but rather a cellulose boiled to the condition of boiled (sodden) rags, and from a chemical viewpoint is clearly distinguished from the hydrate, which is vegetable parchment by the reagents iodine and potassium iodide; the parchment alone, a cellulose hydrate, becomes blue.

Up to now we have only spoken of wood and of the cellulose extracted from it. Without going farther, other problems present themselves when the different ligneous essences are considered as subjects for research: How to recognize the different kinds of wood and the celluloses they yield; the evergreen woods such as pine and fir, and the wood with decaying foliage, of which those chiefly used are the poplar, the birch, and the beech. Every kind of cellulose produced from these different woods should be clearly distinguished.

Besides wood is not the only raw material which produces cellulose. Cellulose can be extracted from other ligneous fibers, particularly herbaceous plants. In Germany it is made from wheat and rye straw; in England and in the rest of continental Europe from esparto grass or alfalfa. This last can be disintegrated by a fermentation analogous to the steeping of flax, but the soda process is principally used. This process only is applied to straw. When the sulphate process is used; i. e., the process when the work of sodium hydrate is completed by sodium sulphate, a 42 per cent yield of a cellulose is obtained, which from its reactions should be considered as an oxycellulose, although it is not as yet very thoroughly understood. In spite of its comparatively weak mechanical resistance as compared to bisulphite cellulose, it furnishes a raw material very applicable for manufacturing letter paper. The problem of the residual lyes is the same as in the case of boiling wood with soda. Really, in the recovery of the alkali, the most interesting question is that of the noxious fumes; but the lyes also doubtlessly contain substances of considerable alimentary value, and further, substances which are gelatinous and have a certain coloring power, of such a kind as to offer one more reason for attempting to utilize these lyes in an advantageous manner.

The considerable development of the manufacture of cellulose, both from wood and straw, gives rise to the fear of a dearth of raw materials in the future. Thus the German cellulose factories are already treating wood brought from the shores of the White Sea. If the devastation of the forests should progress rapidly in the northern countries, the cellulose industry will be stopped by the want of raw materials. There is so much the more reason that our country should be able to furnish the quantity of wood demanded by industry. Besides the available quantity of straw is very limited. The indigenous plants which should furnish large quantities of fiber suitable for paper making are not at our disposal, for the hope of converting turf into a fiber utilizable for paper has proved deceptive. Since considerable capital has been swallowed up in attempts to effect this, it would appear prudent to give it up completely. In any case there still remain reeds; but only for our Austro-Hungarian neighbors. In fact it seems that in the delta of the Danube and in the lower Danube region, reeds are found from which there can be successfully extracted a cellulose analogus to that from straw. In any case it must not be forgotten that the quantity of available fiber here is not very large. Hence for the future of paper making in Germany, we must look to our colonies.

For the moment let us imagine that plants could be treated where they grow, in some way so as to decrease as much as possible the dead weight for transportation, and could be sent to Europe in a half-prepared condition. According to information from an English origin, in Burmah alone there are 60,000 square miles covered with bamboo jungles close to navigable rivers. Granting the rapid growth of these plants, it has been calculated that an area of 16 square miles would be enough to furnish the raw material necessary to make 100 tons of paper per week. It

follows that Burmah, that small part of India, would alone suffice to furnish as much cellulose as the whole world demands.

The scarcity of wood, however, is not yet so pressing that there is any need to introduce the cellulose manufacture in countries with a murderous climate, to consume enormous capital, and to expose it to the difficulties of considerable hand labor. From this point of view America is much better off. Putting aside the fact that in this country it is still possible to devastate the forests on a large scale, instead of having recourse to the creation of a new industry, the short fibers which adhere to the cotton bolls can be used, and the residues and waste of raw cotton, about 600,000 tons of raw material; further, there is still available about 22,000,000 tons of cotton stalks, which have been hitherto considered of no value and are buried by the plow every year. At the same time, and in an analogous manner, the maize stems, wild hemp, marsh herbs, and wild rice are wasted. Some of these American sources already feed the German paper industry. Thus the factories at Bremen treat cotton, utilizing the fibers sticking to the cotton bolls and using them to prepare a product commercially sold under the name of Virgo fiber (thread).

Another very important industry, and to an extent closely allied to the cellulose industry, has also developed greatly—that of artificial silk. That, too, uses cellulose as the raw material. The total natural silk in the world is estimated at 50,000,000 kilograms (110,000,000 lbs.) worth $350,000,000; the production of artificial silk has reached 5,000,000 kilograms (11,000,000 lbs.) worth $20,000,000.

Although the use of natural silk has not yet diminished in favor of artificial silk, the foregoing figures show the growing importance of this new and quite young industry; quite young, for it only began in 1880.

In beginning cotton cellulose was the only thing they dreamed of using. This cellulose was treated with nitric ether (sic, nitric acid), the product thus obtained was dissolved in a mixture of alcohol and ether, and the solution transformed into thread, which, by the use of reducing agents, such as calcium sulphide, was rendered uninflammable. Soon, however, a second process came into use, which consisted in dissolving cotton cellulose in a cupro-ammoniacal solution, spinning this solution, and coagulating it by means of acids or bases. A third process, the production of viscose silk, has lately been added to the preceding ones.

But the development of this industry has not answered to its early promise on account of the high price of its raw materials, viz., wood cellulose, carbon bisulphide, and soda lye; in fact the manufacture is much too difficult. It is only after 12 years of efforts that the scientists, Cross and Bevan, succeeded in making the process practical, and thoroughly mastered what they termed the "maturing" of the viscose. Really, when the three processes were yet in the midst of their development, they encountered a fourth and most serious competitor which came on the scene, although it is true that no marketable product of this process seems yet to have appeared in commerce, that is, silk from cellulose acetate.

While the three kinds of artificial silk mentioned earlier contained only cellulose, regenerated in different ways, in this case the finished thread contained an acetic ether of cellulose. This ether is insoluble in water and, moreover, preserves its mechanical (physical) resistance in presence of water, a quality to which the other artificial silks cannot pretend, except in a very limited degree. The artificial silks from nitrocellulose, from ammoniacal copper, and viscose silk are in themselves less substantial than natural silk, but when they are damp they lose a great deal of the little resistance they possess. This drawback, of preponderant influence, has already made itself felt in dyeing, but it makes itself felt still more during weaving, when the fibers come in contact with water or with damp air. Silk from the acetate does not suffer from exposure to humidity. At first great difficulty was experienced in dyeing because aqueous solutions of coloring matters would not penetrate the fiber, but by using agents which swelled the fiber these difficulties were overcome. There is no need to enlarge on this subject because a short time ago Professor Knaevenagel enlightened us as to the tinctorial properties of acetylcellulose in a very interesting lecture, with experiments, that he gave at Heidelberg at the reunion of the Association of South German Chemists.

All that has been previously said as to the chemical difficulties applies also to the conditions in which the acetate is produced.

The use of acetic anhydride and a little sulphuric acid at the same time, results in the very great instability of the ethereal solutions thus obtained, and this causes more or less fragility of the threads or films which have been produced. Now these difficulties are avoided by various methods. In Knoll & Co.'s patents we find sulphuric acid replaced by benzolsulphonic acid as suggested by Knaevenagel, as well as the addition of neutral salts to the alkaline salts used as regenerators. The effects of these modifications are: To stop hydrolysis which is not desirable, to prevent the destruction of celluloses of large molecular weight, and to obviate any ulterior modification of the physical properties of the product obtained. Aside from the solution of this problem, an appropriate solvent has also been sought for several years. Now acetone and acetic ether have become the regular solvents, while formerly no one dreamed of using anything but chloroform, glacial acetic acid, or analogous liquids, which made the practical use of cellulose acetate very difficult. Thanks to the kindness of Professor Knaevenagel and the firm, Messrs. Knoll & Co., I am enabled to show you here some samples of cellulose acetate and of artificial horse hair, the production of which is still in the experimental stage. At the same

time, I can show you, thanks to the kindness of the color manufacturers, Messrs. Frederic Bayer & Co., a fine collection of sensitive preparations with a cellite (cellulose acetate) base.

As you have already learned at our general meeting at Jena something of cellite films it appears that the problem of the inflammability of kinematograph films (hitherto made of celluloid) has been entirely solved.

The destruction of the cellulose molecule pushed too far during the etherification referred to above, is the cause of great difficulties, not only in the production of acetate, but also in that of Chardonnet's Glanstzoff silks, and of viscose silk, which should be included; in fact, during the regeneration of cellulose, not only cellulose but also a cellulose hydrate is produced. This hydration must be considered as the reason for the weak mechanical resistance of the thread in the presence of water. According to Eschalier, this inconvenience can be avoided by treating viscose with formaldehyde in acid solution. Eschalier is convinced that formaldehyde induces the spontaneous reconstruction of the molecule previously destroyed. According to his figures, the mechanical resistance of viscose silk thus treated is increased in a considerable degree. There still remains the question whether, in spite of the increase in solidity, the elongation (extension) is still sufficient; for it is the low value of these two properties which has hitherto so unfavorably distinguished artificial silks from natural silks. The most important problem in the industry of artificial silks that still remains to be solved is that of endowing them with these two properties.

There is still to be mentioned the complication of questions relating to cellulose hydrates, found in Knecht's recent work on mercerized cotton. He shows that the absorbent power of cotton differs remarkably according to whether during mercerization it has not been dried at all, or has been dried; and if dried, whether this has been done at the ordinary temperature of 100° C. Hence different methods of drying give rise to different hydrates. Also Berl states that if cotton is heated in a current of inert gas at a high temperature, it undergoes polymerization which exerts a favorable influence on the properties of the resulting nitrocelluloses.

These considerations make it sufficiently clear that in the cellulose industry and its allied industries, in spite of the numerous isolated observations, the characteristics of cellulose or the celluloses are very imperfectly known from the chemical point of view. We do not even know the constitution of the cellulose of cotton, which may be taken as the type, and still less of its derivatives—the cellulose hydrates, the hydrocellusoses, and the oxycelluloses. We can only form a vague idea of these bodies. If the cellulose industry is to continue to progress, it is absolutely necessary that a systematic study be made of all the bodies included in the above category.

An advance in the study of their constitution can generally be effected either by the synthesis or the analysis (destruction) of these bodies.

There can be no question at present of constructing a molecule of cellulose, but by destroying an apparent molecule, a certain enlightenment seems to have been obtained. By making decomposition products, we have only a very superficial idea of the cellulose hydrates, but we already know a little more about the hydrocelluloses; we specially know, thanks to Tollens, that when the oxycelluloses are heated with milk of lime (calcium hydrate) they yield dioxybutyric acid and isosaccharic acid; we know that they form sugar by hydrolysis in an acid solution, and by the same method a body representing an intermediary state of transformation between sugar and cellulose—cellobiose.

The theory based on the figures representing these decompositions would be very fruitful, and would be still more so if the researches were made under similar conditions on the large number of celluloses that can be isolated from wood and herbaceous plants. It is highly probable, however, that resort must be had to new methods of research. The future will tell us if these new methods should to some extent encroach on the boundaries of the chemistry of the colloids. In spite of the splendid results found in the domain of the chemistry of the inorganic colloids, it seems as if the organic colloids, cellulose amongst them, would escape from disclosing the secrets of their constitution like so many colloidal substances. Whether it be by purely chemical methods, or by physicochemical methods, there is no doubt, in any case, that those who devote themselves, regardless of the labor, to such serious experimental researches, will have greatly accelerated the progress of the chmistry of cellulose as well as that of pure science, and that the progress of the cellulose industry will likewise be facilitated.

Platinum, which enters the United States free of duty, is figuring more largely in the imports. The 77,637 ounces brought in during the first eight months of 1910 had a value of $2,057,446. The 70,916 ounces imported in same time in 1909 were worth $1,491,570, and the 19,822 ounces in the first eight months of 1908 were worth $546,106.

The world's production of flax fiber in 1907 was estimated at 24,000,000 poods (393,234 metric tons), of which Russia supplied about 254,000 tons, valued at about $33,220,000. The principal purchasers and their average purchases were as follows, in tons: The United Kingdom, 65,540; Germany, 49,154; Belgium, 49,154; France, 40,962.

Consul Albert Halstead, of Birmingham, England, calls attention to the announcement by a British journal of a new rust-proofing process for iron and steel. The article is boiled in 1 gallon of water to which is added 4 ounces of phosphoric acid, and 1 ounce of iron filings.

METALLURGY.

APPLICATIONS OF ELECTROSTATIC SEPARATION TO ORE DRESSING.*

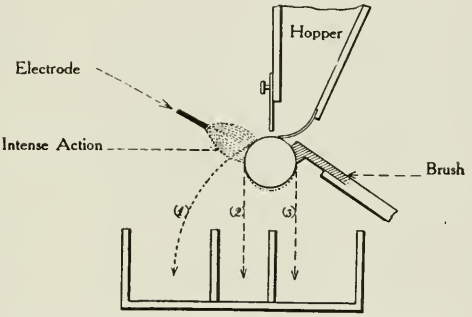
By F. S. MACGREGOR.

The possibility of utilizing the differences in the electrical conductivity of various minerals by giving a part or all of the particles of ore an electrostatic charge has for several years been recognized as a means of separation, and a large amount of experimenting has been done along this line. The commercial application of the art of electrostatic separation has been tried a number of times within the last decade, but until only within about three years has success attended the efforts.

Two factors contributed to this want of success—a lack of the proper means of continuous electrification, and a practical machine and system of treatment designed to meet the rigorous requirements of mill operation. Recognizing these conditions, the Huff Electrostatic Separator Co., of Boston, has perfected several types of separators and a means of electrification which have been a commercial success from their first installation, and at present the entire concentrating and separating machinery of two plants consists of Huff separators—one located at Platteville, Wis., owned by the American Zinc, Lead & Smelting Co., and the other at Midvale, Utah, owned by the United States Smelting, Refining & Mining Co. Also a plant is being installed in Nevada.

The machine consists of a series of separating electrodes placed one above the other. The frame is cast-iron, built in sections, with two electrodes to each section, which facilitates easy shipment and also flexibility in the number of treatments which can be given the ore, and which is dependent on its requirements. A three-section machine (the usual type) is 6 ft. high, 6 ft. 6 in. long, and 18 in. wide. A feed hopper on the top distributes the ore across the first electrode, and it passes by gravity to each succeeding one. The mineral particles receive their charge while passing through a concentrated static field formed by two electrodes—one a grounded rotated shaft, and the other an insulated metal rod. The electrostatic charging of the electrodes is accomplished by a special electrical apparatus (using commercial dynamos and transformers), which, with no more than the usual oiling, gives either a continuous and steady potential of several thousand volts, or an intermittent or pulsating charge of great regularity. The potential, or strength of the field, can be altered at will, according to the conductivities of various ores treated. The figure shows the scheme of separation, the dotted lines indicating *in general* the path of the conductors and non-conductors.

The separating plant at Platteville was started in March, 1908, and was the first plant to be equipped with Huff separators. Although originally built as an experimental plant, it has been in practically continuous operation since then, and used to separate, without roasting, the iron pyrite from the zinc blende, which occur together in varying proportions in southwestern Wisconsin. The ores are milled in ordinary jigs and the lead and lime rock removed. Owing to the nearness in specific gravity of the blende and pyrite, they are recovered in the jigs as a middlings, containing from 10 to 45 per cent zinc, according to the grade of the crude ore, the remaining percentage being iron



Sketch Showing Scheme of Electrostatic Separation.

and the sulphur in combination. Iron above a few per cent interferes with the smelting of the blende, and the function of this plant is to remove this pyrite, making the low-grade ores into high-grade smelting ores.

The plant consists of a wooden, frame building, 9x12 meters (30x40 ft.), and three stories high. On the first floor are the bins for collecting the finished products as they are delivered from the separators. The second and third floors, and in the tower is located the screening system. A spur railroad track runs on either side of the mill, one for cars of raw ore, allowing them to be unloaded either directly into the mill or into storage bins across the track. The other track, which is below the mill level, permits at the same time the loading of empty cars with finished products.

The course of the ore through the plant is shown in the flow sheet, and may be described in detail as follows: It is shoveled into a wheel-barrow in the freight car, wheeled to scales and weighed, then dumped into the feed hopper of the dryer. The top of this hopper is on a level with the car floors to facilitate easy handling of the ore, and at the bottom of this

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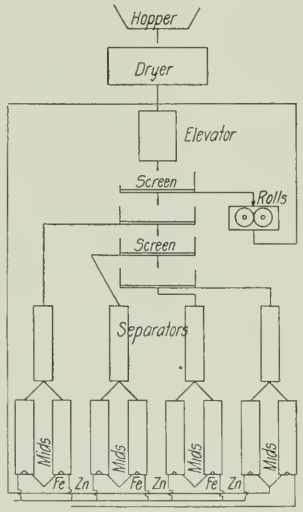
hopper is an adjustable plunger feeder. The dryer is of the cylindrical type, and the shell is 5 meters (16 ft.) long and 0.75 meter (30 ins.) in diameter, rotating about 4½ r. p. m. Being set at a slight pitch, the ore travels gradually to the discharge end, where it emerges bone-dry. As the separation depends on the difference in conductivity of the minerals, it is necessary that all moisture be removed.

A short drag conveyor carries the dried ore to the foot of a bucket elevator, which raises it to the top of the tower and discharges it into a set of screens. There are four, giving an oversize and four other sizes, called A, B, C and D. In general the sizes are as follows:

A size	6 x 5 mesh.	(7 x 8	mm.)
B size	10 x 7 mesh.	(4 x 6	mm.)
C size	24 x 20 mesh.	(0.16 x 0.20	mm.)
D size	50 x 20 mesh.	(0.08 x 0.08	mm.)

The oversize passes through a short trommel to remove any foreign materials, and is spouted to the first



Sketch Showing Course of Ore Through Plant.

floor to a set of rolls, which crush it and deliver it to the boot of the elevator carrying the original feed.

The location of the screens in a tower permits the different sizes to flow by gravity through iron pipe 5 cm. (2 ins.) diameter to the top machine floor. On this floor are located the rougher machines, where the ore is given a rough split, that is, two products are made, one a product higher in zinc than the original feed, and the other higher in iron. Thus, no matter what the grade of the feed to the mill may be (and it varies within wide limits), a fairly uniform mixture is sent to the finishing machines on the floor below.

These finishing machines give the final cleaning to the ore, one set giving a finished iron product, and the other a finished zinc product. The middlings from these cleaners return by gravity to the boot of the elevator and mix with the fresh ore, so that no ore leaves the system that is not separated into its proper grades of product.

The finished zinc product and finished iron product fall into separate bins on the first floor. These bins are V-bottomed, and constructed of two thicknesses of wood flooring with heavy building paper between. They are elevated from the floor so that they may conveniently be drawn off into a 730-kg. (1,600-lb.) capacity push car for loading.

The car is then wheeled to a small elevator and dumped into a hopper on the floor level. This feeds the ore into the boot of a small elevator, which discharges either into a freight car by means of a gooseneck spout, or may be allowed to discharge to a second elevator in the storage bins. From these bins a car may be loaded whenever convenient.

The plant generates its own power, and the engine and boiler rooms are located in an adjoining building. The fire-boxes of the boiler and dryer are side by side, enabling the engineer to look after both fires as well as the engine room. Power is supplied by a Corliss engine, connected to the mill by a clutch.

The plant operates continuously three shifts per day. The labor required per 24 hours is as follows:

3 shift bosses	(8 hours each)
3 machine helpers	(8 hours each)
3 dryer feeders	(8 hours each)
2 loaders	(10 hours each)
2 engineers	(13 and 11 hours each)

There is also a superintendent, master mechanic, assayer, one buyer and bookkeeper, although the buyer and, to a large extent, the assayer devote their time to obtaining custom work.

Two products of marketable value are obtained: The iron pyrite, hitherto valueless in these Wisconsin ores, is sold for its sulphur content, and by reason of its free-burning qualities, makes a very desirable product for the acid manufacturer; and a zinc product which is, of course, sold for spelter. The pyrite is sold by contract, but the blende is sold to the smelters on the open market. With a penalty for excess of iron or lead, one may see it is necessary for such a plant to turn out consistently high-grade products in order to command a satisfactory market price.

The results taken from the "Record of Shipments" for a month show an average zinc product of 55.2 per cent Zn and 3.4 per cent Fe, and a pyrite product of 3.7 per cent Zn and 44.7 per cent S. The average zinc content of the ore, bought and separated into the above products, was 24.1 per cent Zn, and the average iron content was 25.4 per cent Fe. The minimum zinc content was 6.7 per cent Zn, and the maximum 41.2 per cent Zn. The high grade of the separated products shows the flexibility of the process and the ability of the plant to handle any grade of ore from the district.

As a result of the excellent showing of this electrostatic plant, the United States Smelting Mining & Refining Co. decided to put in a plant at their works at Midvale, Utah. The function of an electrostatic plant there is different from that in Platteville, for the ore from the mine of the United States company at Bing-

ham, Utah, contains about 9 per cent of zinc in addition to the gold, silver and lead values.

This ore is shipped to the concentrator at Midvale, where it is crushed and milled by the usual methods of jigs and tables. In this concentration there were formerly two products, one a lead-pyrite product carrying the iron and considerable zinc, and a tailings carrying zinc and some gold and silver values, the object being to keep the zinc as low as possible in the lead concentrate, and yet at the same time make the maximum recovery of the gold, silver, lead and copper values. The zinc added materially to the difficulty and cost of smelting the lead concentrates, and, at the same time, was a total loss. In order to recover this zinc, three products were made in the concentrator, so instead of re-crushing, it is put directly into the finished pyrite. The three sizes, A, B and C, are separated, and the products drawn from the bins on the first floor into tramcars. These are run out of the mill to the loading trestle and dumped into freight cars. The pyrite product is smelted in the United States smelter nearby, and the zinc product is shipped to the Kansas zinc smelters.

The plant is electric driven by a 20 h. p. motor, the 15 Huff separators requiring about 1/3 h. p. each. The generating apparatus for the electrostatic field is located in a small room on the finishing floor. A 3 h. p. motor is direct coupled to a generator, and the strength of field is controlled from a small switchboard. The plant is operated in conjunction with the concentrator,

TABLE OF ELECTROSTATIC SEPARATIONS.

Material.	Product.	% Cu.	% Fe.	% Pb.	% Zn.	% SiO_2	Oz. Au.	Oz. Ag.
Low Grade Chalcopyrite in Quartz	Original	2.56	17.8	...	...	...	0.01	2.6
	Concentrates	5.63	37.0	...	...	...	0.02	5.5
	Tails	0.10	2.0	...	...	...	Trace	0.4
Pyrite and Chalcopyrite in Various Gangues	Original	6.37	25.0	...	...	...	...	..
	Concentrates	9.33	36.3	...	...	...	...	..
	Tails	0.14	1.9	...	...	...	...	..
Chalcopyrite and Bornite in Garnet	Original	3.60	18.6	...	...	32.3	(Iron partly in	
	Concentrates	19.10	25.7	...	...	14.4	Sulphide and	
	Tails	0.34	17.6	...	...	36.7	partly in Garnet.)	
Zinc, Iron and Silver Ore	Original	2.61	23.8	13.9	19.4	...	...	52.8
	Concentrates	3.33	30.7	16.4	6.4	...	...	69.0
	Tails	0.91	3.4	2.7	51.8	...	...	4.6
Zinc, Lead, and Iron Middlings	Original	...	20.2	12.6	23.1	5.2	...	..
	Concentrates	...	31.2	21.0	4.0	3.2	...	..
	Tails	...	2.4	0.5	53.8	8.5	...	..

TABLE OF ELECTROSTATIC SEPARATIONS.

Material.	Product.	% Cu.	% Fe.	% Pb	% Zn.	% S.	% SiO_2
New Mexico Concentrates	Original	2.11	16.2	...	29.9	...	12.9
	Concentrates	5.65	37.2	...	4.9	...	6.6
	Tails	0.13	4.2	...	44.9	...	15.9
Zinc from Above Tailings	Original	...	...	...	...	...	...
	Concentrates	...	...	...	57.1	...	...
	Tails	...	...	...	1.3	...	...
Native Copper in Sandstone	Original	2.68	...	...	...	...	...
	Concentrates	38.70	...	...	...	...	...
	Tails	0.27	...	...	...	...	...
Pyrite Concentration for Sulphur	Original	...	...	...	...	30.1	...
	Concentrates	...	...	...	...	44.8	...
	Tails	...	...	...	...	3.0	...
Middlings from Joplin, Mo.	Original	...	10.8	2.5	49.5	...	...
	Concentrates	...	37.4	9.9	2.9	...	...
	Tails	...	1.6	Trace	62.3	...	...

a lead-pyrite carrying practically no zinc, tailings free from zinc, and middlings containing about 22 per cent zinc, the balance pyrite and some copper, lead, gold and silver.

To treat these middlings, an electrostatic plant was built near the concentrator. It is a wooden frame building, 12x12 meters (40x40 ft.), and covered with corrugated sheet-iron. In general plan it is the same as the Platteville plant—finished ore bins on the ground floors, and two floors of separators. The method of handling the ore is somewhat different. The middlings are shovelled from the table hutches in the wet concentrator into tramcars, which are pushed by hand to the platform elevator at the electrostatic plant. The cars are raised to the third floor level, and, after weighing, are dumped into a 40-ton hopper. This is built over the dryer, and feeds automatically. After drying, the ore is screened as follows: Making A size 12 on 24, B size 24 on 50, C size through 50-mesh.

The oversize is small in amount and very low in zinc, and the superintendence, assaying and bookkeeping is taken care of by the smelter staff.

The average assays of the feed and products are as follows:

	Au. oz.	Ag. per ton.	Cu.	Pb.	SiO_2.	Fe.	Zn.	Ca O.
Crude ore to concentrator	0.08	3.8	0.41	8.4	28.8	14.3	9.0	6.0
Middlings to electrostatic plant	0.05	2.8	1.11	3.3	4.6	24.3	21.6	1.9
Finished pyrite	0.14	4.8	2.24	6.6	..	26.0	9.0	..
Finished blende	0.02	1.5	0.61	2.0	..	3.6	52.9	..

This electrostatic plant not only removes the objectionable zinc from the lead-pyrite concentrate, but makes of it a marketable product, and, instead of being a total loss, it is made to produce a profit. The electrostatic process in these two plants demonstrates two applications in ore dressing, one the custom plant making low-grade ores profitable, and the other as an adjunct to a wet concentrator for the recovery of zinc.

Besides these plants, there is being installed in Nevada a plant working on crude silver ores, wherein the ore goes through no concentrating machinery prior to its electrostatic treatment. The process has been proved applicable to many special problems such as the concentration of copper and lead-silver ores in heavy gangues such as garnet, barite, epidote, etc. The accompanying tables will give some idea of what can be expected with several of these problems.

The perfection of the art of electrostatic separation marks an important step in the dressing of complex or difficultly milled ores.

Considerable progress has been made in Norway in the production of iron and steel by the electric process. A recent consular report gives the following information regarding the work in Norway: Experiments to produce iron and steel from Norwegian ores by the electric process have been made during the last three or four years, partly by aid from the government, in response to a petition sent to the Department of Commerce and Industries by the Christiania Polytechnical Society. Private interest has in this manner been awakened, and the industry now promises to become one of considerable importance. The Norwegian iron ore is often so poor that smelting by the old process was found profitless. The owners of a paper mill at Tinfos, in Notodden, Telemarken, Norway, have for some time been making experiments for the purpose of producing iron by melting iron ore by the use of electricity as the source of heat. The works were completed in February last, and there has already been an output of 250 tons of iron. The ore used has been mined partly at Lango, near Kragero, and partly at Klodeberg, near Arendal. The melting was accomplished by the use of an electric furnace of about 500 h. p. This is the first iron produced by the new process, and in commemoration of the event there has been cast and sent to the Christiania University an ingot of the metal weighing 60 kilos and provided with an appropriate inscription. A stock company, styled the Hardanger Electric Iron & Steel Works, is at present being organized. The capital stock is to be $294,800, of which there has already been sold $160,800. The works are to be located at Ullensvang, in Hardanger, on the west coast, and the object is to produce iron and steel from Norwegian ores by a patented electric process of Swedish origin. The company has secured electric energy from the adjoining water power at Tysse, for a period of thirty years, at a cost of $8.04 per horsepower; 4,200 h. p. will be required. The ore to be used is to be bought from mines in other districts on the best obtainable terms. The transportation of the ore will be found expensive, but it is believed that this drawback will be offset by the cheap power and excellent harbor facilities at the place.

THE DETERMINATION OF LEAD IN NON-FERROUS ALLOYS.*

By C. P. KARR.†

The use of lead in the foundry goes back to the remotest period of human industry. Its general properties are well known and when by intent or carelessness they are violated, the founder soon discovers his mistake without much difficulty; its application within very narrow limits is well understood by all practical metal workers. So important a factor has lead become in every foundry where a diversified range of castings is made that it has been deemed necessary to determine the percentage of that element in any form of alloy in which lead may be present. To accomplish this end chemists have made exhaustive researches to discover assay methods that should be accurate, easily conducted and conclusive. In this paper the methods of assay referred to apply to the alloys into which lead enters in the course of foundry practice rather than to the ores in which lead occurs.

GRAVIMETRIC METHODS.

Alloys not containing tin may be proceeded with directly for the determination of lead, but if tin be present the alloy is dissolved in nitric acid, evaporated to dryness on the water-bath, diluted, allowed to settle, filtered and the filtrate treated with 2 to 3 ccm. of H_2SO_4 evaporated until fumes of SO_3 are driven off, cooled, diluted with 20 to 30 ccm. of water, washed with dilute H_2SO_4 or alcohol or both, dried in the steam bath, precipitate detached from the filter, the paper and the precipitate ignited separately, their ashes united, a drop of nitro-sulphuric acid added, gently dried and re-ignited and weighed as $PbSO_4$, or the precipitate is filtered through a Gooch crucible and dried at 105° C. to constant weight.

This method is very old, but is reliable only in the most skillful hands. In the incineration of the paper filter there are two sources of loss, the oxidation and volatilization of lead and the difficulty of reconverting every particle of the lead reduced by the carbon of the filter back to the form of a sulphate. To overcome these difficulties the Gooch crucible is resorted to. Dr. Bollenbach (Zts. f. anal. chem. 1908, p. 690) states, however, that this sulphate reaction is not very convincing because the precipitate is soluble in strong nitric acid and he proposed the precipitation of lead as a peroxide in an ammoniacal solution by means of bismuth and gives his method in detail. In his paper on the volumetric assay of lead Dr. J. F. Sacher (Chem. Ztg., Dec. 2d, 1909, p. 1257) states that the precipitation of lead as lead molybdate offers an advantage over that of the sulphate method as the molybdate salt is less soluble in water than the sulphate. In a nitrate solution of an alloy not containing arsenic, arsenates nor phosphoric acid, ammonium

*Paper read before the American Brass Founders' Association.
†Chemist Nathan Mfg. Co., New York City.

molybdate may be used directly as a reagent for the quantitative separation of lead. Jannasch (Ber. 26, 2329 and 2331) has proposed a gravimetric separation of lead and copper from a nitrate solution by means of the hydrogen peroxide method, of lead from tin and zinc, metals which are of vital importance, and while these methods are of great importance to the research chemist, they are, on account of the difficulties incurred in the ignition for weighing, of limited used in the everyday routine of the foundry.

About the best example that can be offered of the importance of the gravimetric method is that of the determination of lead in Babbit Metal by Messrs. Walker and Whitman (Jour. Ind. & Eng. Chem., Aug., 1909). Dissolve ½ to 1 gram of alloy in a 250 cc. beaker with 20 ccm. HCL, $5H_2O$ and add HNO_3 a little at a time until the sample is in complete solution. Evaporate to dryness on a steam bath, add 5 ccm. strong HCL (if sample contains 10 per cent or more lead add 10 ccm. HCL), warm a few minutes, stir in 150 ccm. of 95 per cent alcohol, allow to stand at room temperature for 2 hours, filter through a Gooch crucible, wash with about 100 ccm. of 95 per cent alcohol, dry crucible in air bath for one hour at 105° C. Weigh as PbO_2, add 0.0085 grams to the weight of the precipitate and multiply by 0.74473 to find the weight of metallic lead.

VOLUMETRIC METHODS.

Numerous methods have been proposed for this determination, the three most prominent are Alexander's molybdic acid method, as modified by Low, the ferrocyanide method and the permanganate method.

Alexander's original paper was first published in Berg-u-Huttenm., Ztg., 1893, p. 201. Low's modification in Jour. Amer. Chem. Soc., vol. 15, p. 550. He employs a solution of 4.25 grams of the salt to the liter, which if ½ gram be weighed out for the assay corresponds one ccm. to one per cent of lead. Dissolve 0.2 grams of pure lead in HNO_3, evaporate with H_2SO_4, filter off the lead sulphate and wash with dilute H_2SO_4. The sulphate is decomposed with 25 ccm. strong HCL, add 15 ccm. HCL and 25 ccm. water and saturate with 25 ccm. strong ammonia (sp. gr. 0.90). Finally acidify with strong acetic acid, dilute with 200 ccm. of water, heat to ebullition and titrate.

The ferro-cyanide method is carried out with a lead acetate solution acidified with acetic acid and titrate with a ferro-cyanide solution which contains 10 grams of this salt to the liter. One ccm. of solution for a one gram assay corresponds to about one per cent of lead. Titrate till a drop taken taken out with a drop of saturated uranium acetate solution gives a characteristic brown coloring upon a porcelain plate. Low digests the lead sulphate with saturated ammonium carbonate solution to convert the sulphate into a carbonate, cools, filters and dissolves the carbonate in a mixture of 5 ccm. concentrated acetic acid and 25 ccm. water, dilutes 100 cm. water and titrates. If Sb or Bi are present then the lead sulphate is first of all treated with 10 ccm. H_2SO_4 (1:1) and 2 grams of Rochelle salts, add 40 ccm. water and boil. Dr. Bollenbach's method is a modification of the permanganate method (Zts. f. Anal. Chem., 1907, p. 582), but his method is a reversal of all former procedure. In a hot solution of potassium permanganate he adds the lead solution, made alkaline by NaOH, drop by drop to complete discoloration, adds some barium sulphate to facilitate the titration, but his method has recently been studied by Dr. J. F. Sacher, who states that the behavior of $BaSO_4$ towards $KMnO_4$ is completely indifferent and that the method proposed is unreliable. Dr. Sacher advocates the adoption of the molybdate method (Chem. Ztg., Dec. 2d, 1909, p. 1257), which he modifies as follows: To conduct the titration there is required an ammonium molybdate solution of which one ccm. corresponds to 0.01 gram Pb. and a 3 per cent Tannin solution.

In addition there should be a lead nitrate solution containing 16 grams of Pb $(NO_3)_2$ in water to the liter, of which one ccm. corresponds exactly to 0.01 gram of Pb and ready for the back titration when necessary. With this solution the rest of the molybdate titration may be quickly controlled. The tannin solution must be freshly prepared, as it is not unalterable, a 2 per cent addition of acetic acid will prolong its sensitiveness toward the molybdate solution for one week; alcoholic tannin is more permanent and is suitable as an indicator.

Applied to a bronze alloy, for example, the procedure would be to dissolve about 0.5 grams in from 4 to 5 ccm. of HNO_3 (sp. gr. 1.42), evaporate to dryness, dilute with water in the usual way, filter off the metastannic acid, precipitate the copper with the electric current, or as a sulpho-cyanate, and determine the lead in the filtrate from the neutralized nitrate solution. Add 5 ccm. ammonia, dilute to 100 ccm. with hot water, allow to stand on water bath 2 to 3 minutes, add 5 ccm. of 80 per cent acetic acid and titrate hot with ammonium molybdate. The volume of the titrated fluid is carefully measured and the excess in molybdate corresponding to this volume, which occasioned the first yellow coloring with the tannin solution is deducted from the ccm. of molybdate solution found. A concentration below 0.15 per cent Pb is to be avoided, because such a condition makes the end-point indistinct.

In such a case the Colorimetric Method is preferable. The best results are obtained if the precipitate is allowed to settle on the water bath from 2 to 3 hours. To be filtered cold, wash with water till the filtrate shows no more turbidity with the neutral lead solution, dry at 100° C., ignite gently after separate incineration of the filter and weigh after cooling as $PbMoO_4$. A large percentage of iron in the alloy interferes with an accurate result. This may be

avoided by precipitating the excess of iron as a hydroxide in the presence of acetic acid.

A new and simple volumetric method has recently been proposed by Dr. Rupp (Chem. Ztg., Feb. 8, 1910, p. 121), as follows: 20 or 25 ccm. of a half-normal solution of potassium cyanide is rinsed into a 100 ccm. flask, mixed with a suitable volume of lead solution (1 to 5 per cent) free from acid. Fill up to the mark, mix thoroughly, filter after 5 to 10 minutes and titrate 50 to 75 ccm. of the filter with ¼ to ½ normal acid to determine the excess of alkaline cyanide. Use methyl orange as an indicator. If the lead salt solution contains any acid in a free state it is made exactly neutral with dilute NaOH in presence of methyl orange. The foundation equation is $2Cy + Pb'' = PbCy_2$. The calculation is as follows:

1Pb = 2KCy = 2HCL and 0.05178 grams Pb = 1 ccm. N 2KCy = 1 ccm. N/2HCL.

The cyanide solution may be standardized against a pure metallic lead or pure metallic copper in the usual way, using 98 to 99 per cent pure potassium cyanide. The accuracy of the method is ensured by the absence of free acid in the lead solution. For an alloy containing a small amount of lead, say less than 0.15 per cent, the colorimetric method has no rival for accuracy, neatness and dispatch. Iron, however, in the ferric state introduces an inaccuracy. The solution should be dilute neutral and a nitrate. The method is based upon the comparative color intensity of two liquids of the same concentration and volume, of an unknown with a known value. This analysis may take place in one of two ways: A known solution of a definite volume and known concentration may be compared with an unknown solution having the same volume, and, if it have the same concentration, it will have the same depth or tint of color that the known solution exhibits. With colored fluids that are stable a series of concentrated solutions may be kept in readiness as a basis of comparison. In the second method, use is made of the fact that two solutions of different volume densities appear to be equally colored if their concentration is inversely proportional to the intensity of their color. In a special colorimetric apparatus the height of the column of the liquid is altered until both have the same intensity of color and calculate the desired concentration from the proportion of the depth of the two columns.

Method.—Mix the given lead solution with an excess of sulphide solution and select from a series of similarily treated comparative solutions of various, but of known constitution which has been previously prepared from a pure lead nitrate, the one which appears to have the same color for the same volume. Its concentration will be the same as that of the solution which is being tested. Execution.—Use a colorimetric apparatus if possible. Dry at 120° a recrystallized sample of purest merchantable lead nitrate, weigh out 0.0160 grams of it and dissolve in a measuring flask. Dilute to one liter. With the solution (A) containing 0.01 milligram of Pb per ccm., fill up a burette. In graduated cylinders put 40, 30, 20 and 10 ccm. of this fluid, dilute each to 50 ccm. Prepare in addition four other solutions (B, C, D and E), which contain 0.008, 0.006, 0.004 and 0.002 milligrams of lead per ccm. In one of ten about equally wide and high reagent glasses place upon a label a mark removed about 3 ccm. from the edge, and indicate exactly the same (measured from the bottom) height in the same way, in the rest of the nine glasses. Fill up No. 1 with the lead solution to be tested: Nos. 2 to 6 with the comparison solutions A, B, C, D and E. Fill up No. 7 with pure distilled water to the mark. Now, in each of the seven glasses add from 3 to 4 drops of colorless (i. e., 10 per cent) ammonium or natrium sulphide solution, shake or stir the fluids thoroughly, compare the colors. In making the comparison hold or place the two vessels against a background of opaque white glass. The examination should take place in a diffused light of uniform illumination. As soon as it is established between which of the concentrations the unknown lead solution lies, then prepare three additional comparison solutions of intermediate concentration, so that the lead constituent of one to the other bears the relation of about 0.0005. Pour this into reagent glasses Nos. 8, 9 and 10, and compare them likewise with the solution of unknown strength. Set their colors (for example, between those of C and D, i. e., 0.006 and 0.004 milligrams per ccm.), thus the new solutions have 0.0055, 0.0050 and 0.0045 mg. per ccm. Therefore the 27.5, 25 and 22.5 ccm. of the solution A are to be diluted up to 50 ccm. Repeat this until constant results are obtained; the concentration up to 0.0005 mg. of Pb is exactly determined.

If the lead constituent in the given solution rises above 0.01 mg. per ccm., then the sulphide addition causes too great a darkening for the comparison and the fluid is correspondingly diluted. Milligrams of lead should be expressed in ccm. Woudstra (Zts. anorgan Chem., vol. 58, p. 168) states that the method by H_2S is inexact in the presence of Fe. In the Jour. Soc. Chem. Ind. (Jan. 15th, 1910, p. 7), J. M. Wilkie takes exception to the use of a sulphide salt alone as a source of color comparison; he prefers to add a solution of KCy or hydrocyanic acid to the lead solution previously made alkaline with ammonia. Iron present must be in a ferrous state, and ferrous hydroxide must be precipitated under conditions that ensure its intimate contact with KCy. Sodium sulphite is used as a reducing agent. The solution to be tested must be colorless before the alkaline sulphite is added. If the solution to be treated is not acid it is to be acidulated with a few drops of acetic or other acid to a distinctly acid reaction, one ccm. of a 10 per cent solution of KCy is then added and finally a considerable excess of ammonia, if colorless add the sulphide. If the iron is present originally in the ferric state add a few drops of N/10 sodium thiosulphate, heat slowly to incipient

boiling, allow to stand until the color suddenly bleaches out, then add KCy and NH_4OH as usual.

CENTRIFUGIC METHOD.

In the Chemiker Zeitung Repertorium of Feb. 13th, 1909, there was published an account of the Centrifugic Method used successfully by an Italian chemist in the works of Ansaldo, Armstrong & Co., in Cornigliano, Liguria. According to the supposed lead constituent he weighs out from 0.5 to 5 grams of the alloy to be tested, treat with HNO_3 in the same way as in a solution for the determination of lead sulphate, filter off the metastannic acid, evaporate the filtrate with H_2SO_4 until white fumes appear, cool, dilute with 20 ccm. of water. Use a centrifugal apparatus. The tubes used are graduated somewhat similar to that of a burette. A certain factor dependent upon the weight taken is used in obtaining results. If two grams, for example, have been weighed out and the tube reading is at the twelfth division, then by multiplying this reading by the factor 0.2274 the lead content becomes 2.728 per cent of Pb.

Frank Castek (Osterr. Zts. Berg-u-Huttenm., 1909, vol. 57, pp. 665 to 684) uses a phosphorus centrifuge machine and prefers the ammonium molybdate precipitation of lead to that of the sulphate. His conclusion is that applied to ore containing less than 35 per cent using one gram for a determination, the results are concordant, but somewhat too high; 14 tests could be made in 5 hours.

PLANIMETRIC METHOD.

The planimetric method of assay of lead in non-ferrous alloys may safely be described as the latest to arrive among us. It is essentially a microphotographic method. In a non-ferrous alloy containing many ingredients it would be necessary to eliminate tin, copper, antimony and arsenic in the usual manner and reduce the alloy if possible to such a state as to contain but two metallic ingredients, preferably zinc and lead. Obtain a sulphate solution, evaporate to dryness until fumes of SO_3 escape, and transfer the same to a porcelain crucible, reduce and ignite to a prill or button of lead, allow to cool, remove the prill, flatten carefully and etch with dilute nitric or sulphocyanic acid and take an enlarged microphotograph of the same. Prepare several standard microphotographs of lead-zinc alloys or lead alone, or lead and tin or lead and copper, or lead and antimony or lead and arsenic with the planimeter in the usual way, measure the lead area shown by the microphotograph and by the method of proportion compare the areas of lead in the unknown compound with the areas of the known compound. To anyone familiar with operating a planimeter the method becomes exceedingly fascinating, and if the buttons or prills of a known composition are carefully prepared and clearly photographed to scale, the results are accurate and conclusive. The percentage composition is arrived at in the usual way, viz.:

The proportional area of the known composition is to the percentage of the ingredient known as the proportional area of the required ingredient measured by the planimeter is to its required percentage composition.

ELECTROLYTIC METHOD.

Lead is deposited from a strong nitric acid solution at the anode as PbO_2. To facilitate the deposition, the anode should revolve about 500 revolutions per minute. The current density should be about 5 amperes and the terminal pressure between 3 and 4 volts; after ten minutes interrupt the current for some seconds in order to accelerate the reduction of the metallic lead separating at the anode, and repeat this once again towards the close of the assay. After 30 minutes test the solution for lead with ammonium sulphide. When the work is finished, shut off the current, dip the anode wire or gauze in hot water and then in alcohol and dry for an hour at 230° and weigh.

The weight of the PbO_2 found multiplied by 0.866 according to H. J. S. Sand and E. F. Smith, by 0.8643 according to A. Staehler, but by 0.857 according to Hollard and Bertiaux. This discrepancy is due to differences of the thoroughness in the expulsion of the water from the deposit. The question has been carefully studied by H. J. S. Sand. He dried the deposits in a specially contrived drying oven where he could maintain a temperature almost constant between 230 and 240 degrees centigrade. It is my conviction that this empirical factor must be established by a series of experiments that apply to the oven itself, and the conditions under which the assay is conducted. By igniting the PbO_2 to PbO as suggested by Treadwell, which can be done if a platinum dish be used as the anode, this difficulty of drying at a constant temperature may be overcome and with more accurate results. In conclusion the writer would say that the last method is the best of all for rapid, accurate work.

At a recent meeting of the Society of Chemical Industry at Toronto, Ont., Prof. S. F. Kirkpatrick, M.Sc., of the Kingston School of Mines, expressed the belief that the production of an alloy of cobalt and chronium brought out by L. Wood Hynes afforded a most promising prospect for the use of the cobalt product. From this alloy, which contained 75 per cent of cobalt, cutlery bearing a close resemblance to silver could be manufactured. The great advantage of the new metal, Prof. Kirkpatrick said, was that it was non-corrosive and capable of being sharpened, being as firm as steel. Prof. Kirkpatrick also suggested the use of cobalt in place of nickel in the production of German silver.

The ninth and tenth public sales (by tenders) of Billion tin for the year 1910, held at Batavia, Java, resulted as follows. On Sept. 7 there was sold 5,500 slabs, each slab weighing 74.8 pounds, at 33 cts. per pound. On Oct. 5 there was sold 5,500 slabs, at 32.86 cts. per pound.

THE LABORATORY.

LABORATORY HOOD CONSTRUCTION.

By CHAS. R. McCABE.

The prompt and complete removal of the inevitable fumes arising from operations in the chemical laboratory constitutes a problem of prime importance to chemists. Upon its satisfactory solution depends the health of the laboratory force, and to some extent their proficiency as well. And as those who work in the laboratory must suffer from any mistakes of the designer in this regard, the question is also one of moral accountability.

To those who are connected with the best appointed laboratories, the subject will doubtless seem trite and uninteresting. But there are many others who have little reason to take such an attitude. If the sallow complexions and listless manner of many technical chemists do not furnish an apology for calling attention to the subject, a visit to one of the laboratories where they are engaged may suggest an excuse. Here the visitor will find the laboratory hands going about their tasks in an atmosphere vitiated by poisonous vapors almost to the point of suffocation—a condition which they have come to regard as unavoidable, except for such relief as may at times be afforded by the open window. Yet the problem of thorough ventilation is never a difficult or expensive one and failure to solve it satisfactorily is particularly discreditable, especially if the chemist has enjoyed the inestimable advantage of having had a building constructed especially for his use.

Faulty design of the hoods is the most common cause of failure in the ventilation of the laboratory, mistaken ideas apparently being derived by observing the strong draft in the stack of the domestic stove or range. The general character of the stove chimney is imitated in building the hood, it being assumed that success should result from following what is thought to be a good working model. Because the stove has a chimney some 4 or 6 ins. in diameter, with angles and horizontal portions, it seems to be accepted that the hood may be provided with an outlet of the same character. Some even entertain the notion that the stove pipe pattern is not only permissible, but best, not discerning that the stove with its chimney fulfills the conditions necessary to a draft, while the hood and similar chimney do not. This essential truth will become evident if we carefully consider the requirements necessary to a draft in a narrow, enclosed space, such as a flue or stack.

A natural upward draft is due solely to the tendency of hot air to rise. The hotter the air is the stronger is this tendency. The draft thus created is strongest when conditions permit *all* the hot air to rise without obstruction and without being chilled. As the tendency of hot air is only to rise and not to travel about in a horizontal plane, the enclosed space in which a draft is desired should be vertical throughout its entire length. The capacity of this enclosed space (the chimney or flue) should bear a certain relation to the volume of hot air which traverses it, or in other words to the heating capacity of the furnace or stove. If the capacity of the chimney be too great, the hot air is cooled by diffusion, and its tendency to rise is diminished. If it be too small, all the hot air cannot be removed. An ingress of cold air is necessary to sustain combustion and replace hot air removed, but an excess chills the hot air and retards the draft. Bearing these truths in mind, we can readily understand the draft in the stove chimney, and why such a chimney or outlet fails when it is made a part of a laboratory hood.

The stove chimney "draws" not because it is but 4 or 6 ins. in diameter, but because its capacity bears the proper relation to the space in the stove and the amount of heat generated therein. The ingress of cold air is reduced to the minimum by the closed character of the stove, the door being closed at will. The turns and offsets usually seen in the stove chimney are unfavorable to the draft, but other conditions are as a rule sufficiently favorable to overcome their obstructing influence. In the case of the open grate, the vertical flue assists the draft, which is thus made possible despite the free access of cold air. That the open character of the fireplace really does hinder the draft becomes apparent when we recall the familiar device of screening the grate to revive a languishing fire. A grate thus screened represents the ideal conditions for creating an upward draft, and we need hardly be reminded that such a draft is very strong.

Let us now consider the hood designed after the stove chimney pattern and note the conditions under which it must operate.

The space in even the smallest hood is large compared with the ordinary stove, and the heat generated therein comparatively mild. The hood moreover must be open on at least one side all or part of the time. In a word, there are none of the conditions present which give the stove its draft. The stove is closed, while the hood is open. In the stove, the air is intensely hot and has a strong tendency to rise; in the hood, its temperature is low and its tendency to rise

feeble. It is therefore not a matter for surprise that the slightly heated air, carrying the deleterious vapors from analytical operations does not find its way into the open air. Instead it merely fills the hood, but cannot escape on account of the limited capacity of the stack and the angles and offsets which the designer considered allowable or necessary. It has ever been the report of such a hood that "it won't work," and conditions in the laboratory in which it is in service usually make the remark unnecessary.

Some types of inefficient hoods are shown in Figures 1, 2, 3 and 4. Figures 1 and 2 are general types often seen. Figure 3 shows a hood built in a large laboratory in western Pennsylvania. It was entirely unsatisfactory at first, and gave only fair service after a fan

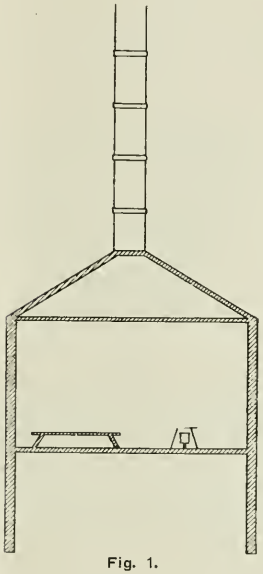


Fig. 1.

had been installed at the extremity of the outlet. Figure 4 shows a hood in a laboratory in eastern Ohio. It is large and open, and has a small stack with an offset; it thus combines every defect and is little better than no hood at all.

A properly designed hood is merely an inclosure in which hot air may rise without hindrance. Obviously, it should not taper abruptly into a small outlet, as in Figure 1; nor should it have a stack or outlet of any character other than vertical. And as the tendency to rise increases with the temperature of the air, provision should be made to prevent the air being chilled by radiation and diffusion. This end is best attained by building the hood no larger than necessary. If the hood is larger than the number of heating appliances required, the air is warmed below the possible maximum according to the amount of unused space.

A few plain rules may now be stated, which when followed have always given excellent results in hood construction, so far as the writer's experience and observation extend.

1. The hood should be as small as practicable. More and smaller hoods should be the rule.

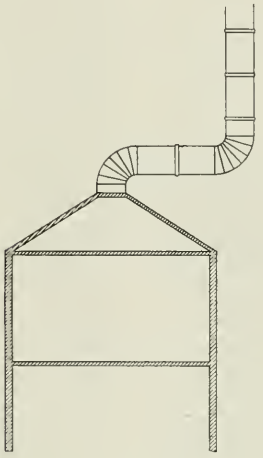


Fig. 2.

2. The stack should be vertical throughout its entire length.

3. That part of the hood which tapers into the stack should not be at too great an angle with the vertical.

4. The capacity of the stack should be adapted to the size of the hood. A stack the area of whose cross-

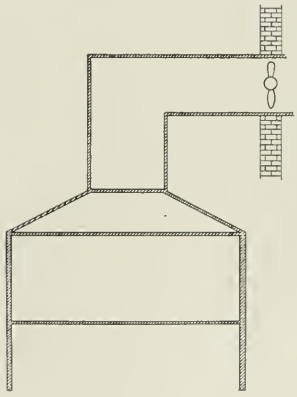


Fig. 3.

section is about one-third that of the base of the hood is best.

5. The open front of the hood should be as small as practicable, and a door provided. Generally the door is unnecessary in a hood of correct design, but should be at hand for emergencies.

Very rarely is forced draft necessary in a hood built

after the foregoing rules. But if desired it may be conveniently and cheaply arranged for by means of compressed air. A small pipe connected with the air line is led into the hood and open into the center of the stack just above its base. A valve on the outside of the hood regulates the blast, which may thus be blown up the stack when required. In this case the hood is best built against a window, which is lowered about six inches at the top. Directly in front of this aperture is the blower. This consists merely of a rectangular frame of pipe having numerous holes drilled in the side facing the aperture. This blower, whose dimensions are slightly smaller than those of the aperture, is connected with the air line and conveniently operated by a valve outside of the hood. The writer has installed this device in the laboratory

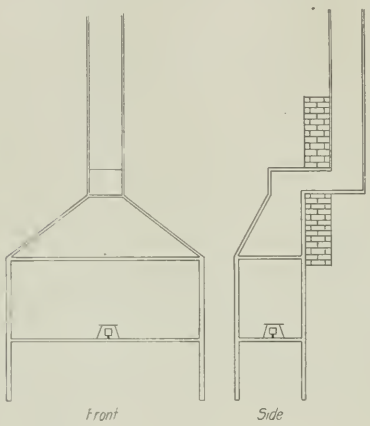


Fig. 4.

of the Lima Locomotive and Machine Company, Lima, Ohio, with very satisfactory results; it draws sufficiently well as a rule without the blower, which is necessary only in windy weather.

It need hardly be suggested that the door and sides of the hood are best constructed of glass.

Figure 5 shows a hood designed according to the principles discussed. A kind of elevated roof or dome may be placed at the top of the outlet to check any downward draft which may be caused by wind.

It frequently happens that the laboratory designer is confronted by conditions which make the construction of a stack without an offset impossible or impracticable. This was the case when the hoods shown in Figures 3 and 4 were built. In each instance circumstances made it necessary to place the laboratory on the first floor of a two-story brick building. To carry the stack through the second floor and roof was too serious a matter to be attempted, so the designer adopted the plan of leading it through an aperture in the wall of the first floor.

In such a dilemma, the true solution of the problem does not lie in a stack of any kind. The most practicable plan is to lead the fumes directly into the open air by means of a fan placed in an opening in the wall at the top of the hood. Figure 6 shows such an inclosure with the fan. It is very efficient. If a window be available for the purpose its upper half may be

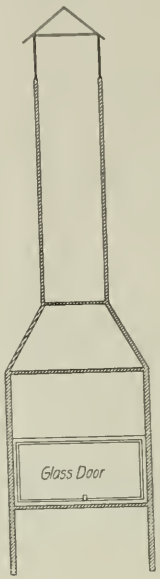


Fig. 5.

built in with wood in which the aperture is cut for the fan. The lower half of the window lights the interior of the hood.

Although the ventilation of the laboratory is a matter of vital consequence, it often does not receive its due share of attention. The idea is prevalent that the

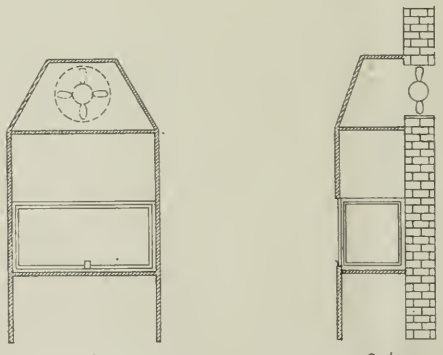


Fig. 6.

fume nuisance cannot be entirely remedied, and must be endured as a matter of course. The truth is that with properly designed hoods and the most approved

methods of ventilation generally, the air in the laboratory may be as wholesome as it is in the ordinary living or working room. Though an occasional escape of vapors into the room, due to haste or accident, may be expected only lack of study on the part of the laboratory builder can explain the nuisance in a chronic form.

The attention of the profession may with profit be drawn to the fact that the principles which should be grasped in building the hood were long since discovered and employed in building the common fireplace with its flue. The combustion of a few pounds of coal produces an enormous amount of smoke and dangerous gases, yet the fireplace and flue effectively remove every trace from the living room. And just as efficiently will the properly designed hood, which is indeed only a fireplace in form, relieve the laboratory of those noxious vapors which are inseparable from analytical operations.

THE USE OF SILVER PHOSPHATE AS A STANDARD FOR PHOSPHORIC ACID AND A CRITICAL STUDY OF THE GRAVIMETRIC MAGNESIA METHOD FOR ESTIMATION OF PHOSPHORIC ACID.

By W. C. DUMAS.*

PART I.

The details for the determination of phosphoric acid given in the official gravimetric method are very meager and those found in text books are not much fuller, so different chemists working in different laboratories often vary very widely in their results on phosphoric acid. There are fine points in this method which have to be carefully regulated in order to obtain the precipitate of normal composition with magnesia mixture thus giving a normal pyrophosphate after ignition, and consequent correct results for phosphoric acid. If the results for phosphoric acid on a co-operative sample of phosphate rock are examined, often a very wide variation between different laboratories will be noticed. Those who have much to do with phosphate rock know the "constant," as it were, of the different chemists, and they say they can predict how far different chemists will be apart on phosphoric acid on the same sample. This is due to important differences in what would seem minor details, and is a distressing state of affairs, reflecting small credit on those doing the work. Every chemist stoutly maintains that his results are correct because he has determined his results along with a rock which he calls a "standard," but which oftentimes is standard to him only. This sample has given the same results which it always did, therefore his determination on the rock under investigation is correct.

The content of phosphoric acid in the standard samples of rock which are used as controls has also been determined by the same method as that used on the unknown sample, so it cannot be relied on as being correct unless the sample itself has been analyzed under the proper conditions. Thus the standard sample is often open to the same criticism as the unknown. Endless controversies thus arise because the chemist has not used a standard which contains an absolutely constant amount of phosphoric acid, by which to test the method.

These are only a few preliminary results bearing directly on those points in dispute among chemists. In the search for a proper standard none could be found better than tri-silver phosphate. It is easy to prepare pure, can be dried for any length of time at 105° C without decomposing, is non-hydroscopic and contains about the same percentage of phosphoric acid as an acid phosphate—16.96 per cent. The silver phosphate was prepared according to the method used at Harvard in the atomic weight work on phosphorus, and dried at 105° C for three or four hours, then preserved in a black bottle in the dark. For the following determinations, the standard solution was prepared as below: Two grams were accurately weighed into a 250 cc. flask and dissolved in as little dilute HNO_3 as possible. The solution was then diluted to about 175 cc. and the silver precipitated with dilute HCl. The AgCl was filtered out and washed well, the solution cooled and made up to 250 cc. For the determinations, 25 cc. portions equal to 0.2000 gram of silver phosphate were used. The 25 cc. pipette was checked against the 250 cc. flask, so that the portions taken were exact aliquots.

The regular gravimetric method was tried on this standard sample except just before adding magnesia mixture, the solution was made as near neutral as possible by the addition of dilute HCl. The acid was added until there was a slight precipitate remaining undissolved for several minutes

By this procedure the results shown in Table I were obtained.

TABLE I.

Per cents of P_2O_5 found.....	16.96	16.96	16.93
Theoretical per cent present.....			16.96

In these analyses the pyrophosphates were blasted three minutes and lost nothing on a second blasting. In this connection see the results on the blasting of the pyrophosphate in the Part 2 of this paper.

Finding that this procedure gives correct results when the neutrality is carefully regulated, the effects of different variations which might easily take place in the course of an analysis were tried. The points investigated were these. 1st—The effects on the results due to the different states in which the magnesium ammonium phosphate is precipitated such as crystalline, or in large or small flocks; 2nd—The effect of small amounts of ammonia if the solution is not neutral just before adding magnesia mixture; 3rd—The effect due to different rates of adding magnesia mixture; 4th—Effect likely to take place due to slight fusing of the

pyrophosphate; 5th—Time necessary in standing after the excess of ammonia has been added.

In the results obtained in Table I, two of the precipitates of magnesium ammonium phosphate were flocculent, one large flocks and the other small, while one of the precipitates was distinctly crystalline. No difference in results from the theoretical could be detected due to these different crystalline conditions. Under apparently the same conditions of neutrality, rate of addition of magnesia mixture, etc., the precipitates are often very different in appearance, yet the results always seem to indicate that this makes small difference in the correctness of the results.

Next, several determinations were run, in which, after getting as neutral as possible, a known amount of ammonia was added in order to find out the effect of this small alkalinity; 1 cc. of 0.96 sp. gr. ammonia water was added here and the determinations finished as before.

TABLE II.

				Aver.
Per cents of P_2O_5 found.....	16.73	16.90	16.65	16.76
Theoretical per cent present..				16.96
Difference				0.20

In these and other determinations at different times it is noticed that when even slightly alkaline the results are always low. Some light can be thrown on this by the considerations for the composition given in the second part of this paper.

In all the above determinations, the magnesia mixture was added at about the rate of two drops per second with vigorous stirring. Table III shows two results when the mixture was added more rapidly—6 to 7 drops per second.

TABLE III.

Per cents of P_2O_5 found.....	17.03	17.12
Theoretical per cent present.....		16.96

These results, as is seen, are too high, due in all probability to a co-precipitation of magnesium hydroxid.

In several determinations during the course of this work, the pyrophosphate slightly fused, and in one or two instances fused entirely. This fusion is due to some slight impurity, but as a very small amount of impurity is sufficient to cause this, the results were almost identical with those that did not fuse.

In all the above determinations, the precipitated magnesium ammonium phosphate was always allowed to stand at least two hours before filtering, and as the results are practically theoretical, this seems to be long enough.

PART II.

The results on the determination of phosphoric acid, as shown by the above work on silver phosphate, as well as by miscellaneous observations from time to time, always seem to be about 0.20 per cent too low, when the magnesium ammonium phosphate is precipitated in an alkaline solution, indicating that under these conditions, the magnesium ammonium phosphate formed, is not of the normal composition. The work reported here was undertaken to see if these variations so often observed could be accounted for. The gravimetric magnesia method has been in use a long time and is often considered to be so nearly perfect as to be above criticism. The results obtained show that there are several factors influencing the composition of the magnesium ammonium phosphate, and of course the correctness of the whole method depends on the composition of the unignited precipitate. These factors will be discussed in detail and some data about magnesium ammonium phosphate presented.

Three sets of magnesium ammonium phosphate were first prepared. The conditions of preparation were varied as given below. For convenience these samples may be designated as A, B, C and D.

Sample A.—To a weighed amount of di-ammonium phosphate, molybdic acid was added in the proportion found in an ammoniacal solution of ammonium phospho-molybdate. This solution was then made exactly neutral and an amount of magnesia mixture a little in excess of that necessary to precipitate the phosphoric acid was dropped in slowly, while the solution was vigorously stirred. After the solution had stood for 15 minutes and the magnesium ammonium phosphate had settled, an amount of concentrated ammonia equal to one-third the volume of the solution was added. The solution was then allowed to stand one hour before washing.

Sample B.—A weighed amount of di-ammonium phosphate was dissolved in a measured volume of water, and molybdic acid added in the same proportion as would be present in a determination. The solution was then first made neutral, and then for every 50 cc. of volume there was added 1 cc. of 0.96 sp. gr. ammonia water. The magnesium ammonium phosphate was then very slowly precipitated with a slight excess of magnesia mixture, and after 15 minutes, concentrated ammonia equal to one-third its volume was added. This sample was also allowed to stand one hour before decanting.

Sample C.—This precipitate was prepared from a neutral solution of di-ammonium phosphate without any molybdic acid. After 15 minutes it was treated as Samples A and B.

Sample D.—Prepared from an alkaline solution of di-ammonium phosphate (1 cc. 0.96 sp. gr. ammonia per 50 cc. solution) without the presence of molybdic acid. It was treated as the other three samples.

After thes precipitates of magnesium ammonium phosphate had stood for one hour or more, the supernatant liquid was decanted, and the precipitates washed entirely by decantation until free from chlorides as tested by acid silver nitrate reagent. These precipitates now had to be thoroughly dried for analysis. They lose ammonia and water of crystallization at 100° so it was necessary to dry them at ordinary temperatures over sulphuric acid. This decomposition of the magnesium ammonium phosphate will be referred to later. After washing, the precipitates were placed in a vacuum desiccator until the water had dried

out and they had hardened into a cake. They were then pulverized and allowed to stand over sulphuric acid for a month, so as to be perfectly dry.

The precipitates were then analyzed for phosphoric acid, magnesia, ammonia, and water of crystallization in order to note the effect of the conditions of preparation on the composition. The methods of analysis will not be given here, but they were independent of the errors found in the magnesia method. Of course an abnormal composition will affect the analytical results when phosphoric acid is determined by the gravimetric magnesia method, so it is necessary to obtain data on the conditions most favorable to the formation of a precipitate of the normal composition.

The composition of the normal magnesium ammonium phosphate is $MgNH_4PO_4.6H_2O$. Table IV gives the theoretical composition and the compositions of the four sets of samples prepared as outlined above.

TABLE IV.

Constituent.	Theoretical Comp.	Sample A—Neut., with MoO_3	Sample B—Alk., with MoO_3	Sample C—Neut., no MoO_3	Sample D—Alk., no MoO_3
MgO	16.44	16.44	16.23	16.74	16.80
NH_3	6.93	6.88	6.76	6.68	6.44
P_2O_5	28.94	28.94	29.80	33.77	32.75
Combined H_2O	44.62	44.07	43.18	37.64	39.22

These results are averages of three or four well agreeing figures. The figures were obtained with the greatest possible care and should represent the composition of the several lots.

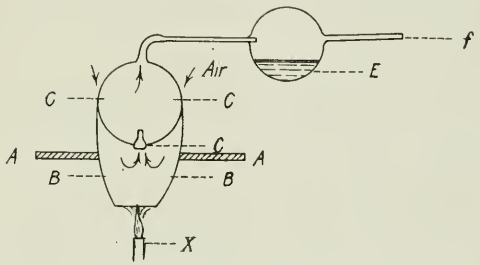
From Table IV, it will be seen that the only precipitate having the normal composition, $MgNH_4PO_4.6H_2O$, is A, precipitated in the presence of molybdic acid and from a neutral solution. In B, where there was a considerable proportion of ammonia present, the percentage of phosphoric acid is 0.86 per cent above that of the theoretical, while the ammonia is 0.17 per cent lower than theoretical. These facts account for the low results obtained in an analysis where the magnesium ammonium phosphate is precipitated in the presence of even a slight excess of ammonia. The reason for the low result in a precipitate of this composition, is that the phosphoric acid in the compound is about 0.86 per cent in excess of what it should be, and the MgO is 0.21 per cent lower than theoretical. Now when a magnesium ammonium phosphate of this composition is blasted, the first loss is that of water and ammonia, but on continued blasting the phosphoric acid in excess of that necessary to form $Mg_2P_2O_7$ with the MgO present is volatilized. That the resulting magnesium pyrophosphate from the ignition of the magnesium ammonium phosphate prepared from alkaline solution is normal was demonstrated by analysis.

The products of combustion were caught and tested for phosphoric acid in an apparatus like that shown in the cut.

All the precipitates prepared were tested. The platinum crucible, B, of about 50 cc. capacity, was tightly fitted into a thick disk of asbestos board, A, fixed directly above the blast lamp, X. C is a bulb which just fits into the top of the crucible and has its opening, c, about half way down the crucible. E is a second bulb containing ammonia water. In these volatilization tests for phosphoric acid, 0.25 gram portions of the precipitates of magnesium ammonium phosphate were used. This amount was weighed into the crucible, the bulb fitted in, and the tube, f, connected to the filter-pump, which gave a gentle flow of air through the bulbs, thus carrying upward any phosphoric acid volatilized. The air entered the crucible around the edge of the bulb as shown by the arrows. The crucible was then blasted until a constant weight was obtained.

After the completion of the blasting, the bulbs were rinsed out first with ammonia, and then with nitric acid. Care was taken to prevent any contamination of the test by phosphoric acid from the laboratory. The washings from the tubes and bulbs were then tested with molybdic reagent for phosphoric acid.

The precipitate, A, which showed a theoretical composition, and the precipitates C and D, which contain



Apparatus for Testing for Phosphoric Acid.

an excess MgO, gave only the slightest trace of phosphoric acid volatilized, but the precipitate, B, prepared from alkaline solution, and showing an excess of phosphoric acid by analysis gave a very positive test for phosphoric acid.

Now, in the precipitate, B, the MgO is 0.21 per cent too low, due to the 0.84 per cent excess phosphoric acid. Suppose 0.25 gram of the magnesium ammonium phosphate prepared from an alkaline solution was used for analysis, which is about the same thing as using 0.25 gram of phosphate rock for a phosphate rock analysis, as they contain approximately the same percentage phosphoric acid, then in this 0.25 gram there is a deficiency of 0.0005 MgO which itself is equivalent to 0.0013 grams of magnesium pyrophosphate. So instead of the 0.25 gram of this compound giving 0.1134 grams of magnesium pyrophosphate, it will only give 0.1121 grams. This will lower the result by 0.34 per cent phosphoric acid, or 0.74 per cent $Ca_3(PO_4)_2$, if the magnesium ammonium phosphate has been precipitated from slightly alkaline solutions. About this same difference was obtained in all the results on silver phosphate when an alkaline solution

was used in precipitating the magnesium ammonium phosphate. Of course, the remarks above will apply equally as well to a phosphate rock.

Taking the excess percentage of phosphoric acid in the sample, B, and calculating from it and from the deficiency of MgO and ammonia, we can obtain the weight of magnesium pyrophosphate which 0.25 gram should give, and this result agrees well with the amount actually obtained in blasting to a constant weight.

TABLE V.

$Mg_2P_2O_7$ from 0.25 gram of B after blast to constant weight.	Calculated for 0.25 gram of sample B
0.11210	0.11195

These facts explain why the results in analytical work are often low, when the alkalinity of the solution is not carefully controlled before adding magnesia mixture.

The sample, A, prepared from neutral solutions in the presence of molybdic acid was normal in all respects.

The compositions of Samples C and D were rather peculiar. C was prepared from neutral solutions without molybdic acid and D in alkaline solutions without molybdic acid. The analytical results on these two samples are given in Table VI.

TABLE VI.

	C—Prepared from neut. solution without molybdic acid.	D—Prepared from alkaline solution without molybdic acid
MgO	16.76	16.80
NH_3	6.68	6.44
P_2O_5	33.77	32.75
H_2O (combined)	37.64	39.22

The proportions in Sample C can be represented by the formula, $Mg_{11}(NH_4)_{10}(PO_4)_{12}{\cdot}53H_2O$, and those in D by $Mg_{11}(NH_4)_{10}(PO_4)_{12}{\cdot}57H_2O$, which gives the theoretical composition shown in Table VII as against results in Table VI.

TABLE VII.

	C—Prepared from neut. sol. without MoO_3 $Mg_{11}(NH_4)_{10}((PO_4)_{12}{\cdot}53H_2O$	D—Prepared from alkaline solution without MoO_3 $Mg_{11}(NH_4)_{10}(PO_4)_{12}{\cdot}57H_2O$
MgO	17.34	16.98
NH_3	6.68	6.49
P_2O_5	33.52	32.57
H_2O (combined)	37.53	39.24

These formulas serve to picture the proportions correctly, but may not represent the actual way in which the constituents are combined. The weights of magnesium pyrophosphate obtained by blasting to constant weight samples of the compounds, C and D, agree well with those which a given amount should give when calculated from the above formulas. Quite often it seems that molybdic acid in solutions from which magnesium ammonium phosphate is precipitated has a marked effect on the composition when the compounds form slowly. This is not always true, as the percentages of Mgo and P_2O_5 may vary considerably. One sample was made from a solution containing no molybdic acid which had the normal composition. So it is certainly possible to make magnesium ammonium phosphate from solutions of di-ammonium phosphate and magnesia mixture by regulating the conditions just right, but they seem to vary more in their composition than those made when molybdic acid is present.

EXPERIMENTS IN IGNITING MAGNESIUM AMMONIUM PHOSPHATE AND IN BLASTING MAGNESIUM PYROPHOSPHATE.

In the course of some analyses when the magnesium pyrophosphate was blasted for five minutes to get a constant weight, it was noticed that on a second blasting of five minutes that there was a further loss of one or two-tenths of a milligram. It seemed interesting to determine the time necessary for the pyrophosphate to reach a constant weight. This time was determined for a large number of samples of magnesium ammonium phosphate, and it is quite certain that a constant weight is not reached under a period of blasting of fifteen minutes. In a few instances in the course of analysis, a constant weight was reached after ten minutes, and many times not under thirty minutes. Some of these experiments in blasting are given in Table VIII. An examination will show that most of the volatile substances are driven off during the first five minutes of blasting, then for each successive period of five minutes the loss is from two to three-tenths milligram until the final constant weight is reached.

From the results in Table VIII on samples of magnesium ammonium phosphate prepared under various conditions and of different compositions it appears that the constant weight is often not reached under

TABLE VIII.—TIME OF BLASTING PYROPHOSPHATE TO OBTAIN CONSTANT WEIGHT.

0.2500 gram mag. ammon. phos. used which should give theoretically 0.1134 gram magnesium pyrophosphate.

A Neut. Solution and Molybdic Acid.		B Alkaline Solution and Molybdic Acid.		C Neutral Solution, no Molybdic Acid.		D Alkaline, no Molybdic Acid. 0.50 gr. used.	
After 5 min.....	.11505	After 5 min.....	.11455	After 5 min.....	.11485	After 5 min.....	.2332
After 11 min.....	.11480	After 10 min.....	.11435	After 20 min.....	.11460	After 11 min.....	.2326
After 16 min.....	.11455	After 15 min.....	.11405	After 25 min.....	.11440	After 16 min.....	.2322
After 21 min.....	.11430	After 19 min.....	.11365	After 30 min.....	.11440	After 19 min.....	.2319
After 23 min.....	.11425	After 24 min.....	.11335	Correction	.00020	After 22 min.....	.2318
After 30 min.....	.11395	After 29 min.....	.11315		———	After 25 min.....	.2318
After 35 min.....	.11360	After 34 min.....	.11285	Final weight.....	.1146	Final	0.2318
After 38 min.....	.11340	After 45 min.....	.11255	Theoretical weight for		Theoretical weight for	
After 40 min.....	.11330	After 51 min.....	.11195	0.25 grm.....	0.1134	0.50 grm. is.....	.2268
After 42 min.....	.11330	After 54 min.....	.11195	Time—25 minutes.		Time—22 minutes	
Final weight.....	0.1133	Final weight.....	.11195				
Theoret. for 0.25 grm. of precipitate.....	.1134	Theoretical for 0.25 grm. of precipitate.	.1134				
Time—40 minutes.		Time—51 minutes.					

thirty minutes of blasting. The sample, A, which is of normal composition, requires 40 minutes of blasting to reach a constant weight, while sample, B, containing a higher percentage of phosphoric acid than theoretical requires fifty-one minutes of blasting. This is due partly to the time necessary to volatilize the excess phosphoric acid. Samples C and D, which contain an excess MgO, do not require as long as the compounds of the normal composition.

In Table IX are given the results on some precipitates of normal compositions. The first weights in the table are the weights of the pyrophosphate after the first period of blasting. These examples are from

The amount of free ammonia in solutions from which magnesium ammonium phosphate is precipitated does not have to be very much to cause the precipitation of this compound having an abnormal composition, and an excess phosphoric acid. One cubic centimeter of 0.96 sp. gr. ammonia water in 50 cc. of solution is sufficient to prevent the formation of a normal magnesium ammonium phosphate. On one lot, first prepared, with only half a cubic centimeteer per 50 cc. of volume, composition was not normal, while another sample prepared at the same time was normal in every respect.

The final details decided on for the gravimetric de-

TABLE IX.—TIME FOR PRECIPITATES OF NORMAL COMPOSITION TO REACH CONSTANT WEIGHT.

No. 1.		No. 2.		No. 3.	
After 10 min.	0.1034	After 10 min.	0.1064	After 7 min.	0.1057
After 20 min.	0.1027	After 15 min.	0.1062	After 10 min.	0.1057
After 25 min.	0.1026	After 18 min.	0.1061	Time—7 minutes.	
After 30 min.	0.1026	After 20 min.	0.1061		
Time—25 minutes.		Time—18 minutes.			

actual determinations of phosphoric acid in unknown substances.

From Table IX it is seen that the time necessary to obtain a constant weight varies considerably. This time varies even when all precautions are taken to have all the conditions alike. Perhaps the loss depends upon some very slight variation in composition or impurity contained which cannot be detected by analysis. No. 1 shows a period of 25 minutes to become constant, No. 2 20 minutes, while No. 3 required only 7 minutes. All precipitates were supposed to be alike. Even a constant weight has been obtained after three to five minutes of blasting, but this is not often the case. Usually when the loss is not more than one or two-tenths of a milligram on the second blasting, the blasting is considered as finished, when as a matter of fact, the precipitate might continue to lose one or two-tenths of a milligram for subsequent like periods of blasting as long as 20 to 25 minutes. These results show that the practice of blasting five minutes additional after the first blasting and taking this weight as correct is very dangerous in practice.

In some of the blasting experiments there was an incipient fusion. Some of the pyrophosphates from magnesium ammonium phosphates of the normal composition partly fused on blasting, but this fusion seems to have slight effect on the results as for 0.25 grams of the magnesium ammonium phosphate, the theoretical 0.1134 grams of pyrophosphate was obtained. The magnesium ammonium phosphate, B, prepared from alkaline solutions fused to a greater extent than any of the other precipitates. Those samples, C and D, having an excess MgO did not fuse at all over the blast. A slight fusion in an analysis does not necessarily mean, as some think, that the result will be low. This is also shown by the analytical results on silver phosphate. If a precipitate fuses considerably it is an indication that the magnesium ammonium phosphate was not of a normal composition to begin with.

termination of phosphoric acid by the magnesia method is as follows: In a phosphate rock, 0.25 gram portions of the rock are used for several reasons. With a good balance this amount is enough. The weight of pyrophosphate obtained is about 0.12 of a gram, and this amount can be more quickly blasted to constant weight than a larger quantity. The method followed is as usual until after the ammonium phospho-molybdate has been washed. This is then dissolved in the smallest possible amount of ammonia while stirring it up on the filter with a fine jet of hot water. The filtrate is made as near neutral as possible with very dilute HCl until the yellow precipitate will just dissolve after three or four minutes. The magnesia mixture is then run in at about the rate of one or two drops per second while the solution is constantly stirred. The beaker is allowed to stand for 15 minutes in this nearly neutral solution and then one-third its volume of concentrated ammonia is added. It is then allowed to stand two hours before filtering. To obtain the best results the magnesia mixture should not be old. The precipitate is then filtered off, washed with dilute ammonia water, ignited and blasted to constant weight.

SOME PROPERTIES OF NORMAL MAGNESIUM AMMONIUM PHOSPHATE, $MgNH_4PO_4.6H_2O$.

This salt when prepared and dried at ordinary temperatures is a beautiful snow-white compound consisting of very minute crystals. When exposed to the air, it is only very slightly hydroscopic, but not more so than any other very finely divided powder. Half of a gram exposed to the air of the laboratory gained six-tenths of a milligram in 10 minutes. It is stable at ordinary temperatures and does not lose its water of crystallization. No loss of water of crystallization was detected after it had stood for two months. This magnesium ammonium phosphate when prepared from a solution which is neutral settles very rapidly, while, if the same solution is alkaline, the settling is much

slower. The alkalinity has an effect on the physical form of the crystal as well as on the chemical composition.

Roscoe and Scholermann state that the normal magnesium ammonium phosphate, $MgNH_4PO_4.6H_2O$, loses five molecules of water of crystallization at 100 degrees and no ammonia. In an attempt to prepare the dry salt by drying at 100 degrees, it was noticed that there was a strong odor of ammonia. In order to determine the extent of this decomposition at 100 degrees, weighed samples of the magnesium ammonium phosphate were heated, the loss determined, and the ammonia determined in the residue after heating. All the results obtained point to the loss of five molecules of water and two molecules of ammonia from three molecules of the salt. The decomposition may be represented thus:

$MgNH_4PO_4.6H_2O$ ....$2NH_3$....$15H_2O$.... $HMgPO_4$
$MgNH_4PO_4.6H_2O$ $HMgPO_4$
$MgNH_4PO_4.6H_2O$ $NH_4MgPO_4.3H_2O$

TABLE X.

	Theoretical loss as above.	Loss actually found.
Per cent water lost.....	36.68	36.57
Per cent ammonia lost.....	4.62	4.79
Total loss at 100.....	41.30	41.36

The percentages are on the basis of the unheated compound. To further test the correctness of the above equation the percentage of ammonia was determined in the remaining compound. This compound which remains after heating is $(MgHPO_4)_2NH_4MgPO_4.3H_2O$, which contains 3.93 per cent ammonia. The analytical average of three determinations gives 3.70 per cent ammonia, so it is probable that the decomposition is correctly represented as above.

MISCELLANEOUS OBSERVATIONS ON THE MAGNESIA METHOD.

A few observations of a miscellaneous nature may not be amiss here. The magnesium pyrophosphate is not hydroscopic in the least, and can be exposed to the air for 15 to 20 minutes without attracting an appreciable amount of moisture. As two or three-tenths of a milligram variation in the weight of the pyrophosphate will make a difference of about .08 per cent phosphoric acid or 0.18 per cent phosphate of lime in a phosphate rock where a quarter of a gram is used for analysis, great care should be taken to weigh the crucible under the same conditions at all times. The method usually followed is to allow the empty crucible to remain on the balance pan until the weight becomes constant, then after the blasting of the pyrophosphate to weigh in the same way. This gives the same amount of condensed water on the crucible's surface both times. The non-hydroscopicy of the pyrophosphate makes this possible. It is found best to work on portions of phosphate rock equal to one-quarter of a gram, and to get the final weight to one-tenth of a milligram. This small sample enables the analysis to be handled better, the washing of the precipitates is more thorough, and the time of blasting is not so long.

SUMMARY.

To sum up the above results the following principal points are given.

1. Magnesium ammonium phosphate can vary considerably if the conditions of its precipitation are not closely regulated. The normal composition can be best obtained by precipitating from as near neutral solutions as possible very slowly.

2. When precipitated from even slightly alkaline solutions, the composition is often abnormal with a high percentage of phosphoric acid and low magnesia.

3. When such a precipitate is ignited and blasted there is a loss of phosphoric acid by volatilization which causes analytical results often to be low.

4. When precipitated rapidly from either neutral or alkaline solutions, the phosphoric acid is low and the magnesia high in magnesium ammonium phosphates.

5. Magnesium pyrophosphate requires considerable time to come to constant weight on blasting, and often does not reach it under half an hour of continuous blasting.

6. Magnesium ammonium phosphate loses water and ammonia at 100 degrees in the amounts given in the paper.

7. Silver phosphate is the best standard for regulation in work on phosphoric acid.

8. Miscellaneous observations are given.

A recent consular report states that the Electro-Metallurgical Commission of Norway has completed its work and filed its report. In speaking of the work of the commission Professor Farups, of the University of Christiania, one of the members, is quoted in the consular report as stating: "It is quite possible for us, in electric smelting of iron ore, to compete with smelting ovens of the old type in other countries. The iron ore is no more expensive here than in other places, and Norway is richer in electric energy, and electric power here is much cheaper than in other countries. Besides, we have very good export seaports, with our waterfalls and electric power close to the sea. Should the electric smelting of iron and steel, in spite of all this, become more expensive than smelting by the old methods, it will still be able to compete with the old method of smelting because of the much finer quality of the product. In Sweden, where the new electric smelting ovens have been installed, the results show that the new method is a success and in an advanced stage of progress, and Norway will, with her electric power and transportation facilities have many advantages over Sweden."

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NOTES AND COMMENTS.

NORTH DAKOTA LIGNITE AS A FUEL FOR POWER-PLANT BOILERS.

A bulletin recently issued by the U. S. Bureau of Mines describes a series of tests of lignite as a fuel at the pumping plant of the United States Reclamation Service at Williston, N. D. The Reclamation Service has a large project there and had installed steam boilers with furnaces designed to burn a "brown lignite" that was mined on adjacent government land.

The furnace is of the semi-gas producer type and has an external resemblance to the so-called Dutch oven. The most striking features in its construction are the deep-set grate and the construction of the space between the bridge wall and the end of the prolonged fire brick arch. The furnace is designed to work on the gas-producer principle. The solid fuel is gasified on the grate and the gas passes through the space under the arch into the combustion chamber where most of the gaseous combustible burns.

The results of the tests on the lignite show that this fuel, though generaly considered unsatisfactory, may be used with fair economy under boilers that generate their full rated capacity. In fact, when the number of heat units available is considered, the results compare favorably with those of better grades of fuel.

The tests are deemed important because the lignite deposits of the Northwest are so extensive and the distance of the region from other coal fields is so great that a large portion of the United States, including parts of North Dakota, South Dakota and Montana, may be greatly benefited by any improvements in the methods of utilizing this local fuel supply. The lignite in this field is low in heating value, some of it containing nearly 45 per cent of its weight in moisture, and it is difficult to burn in the furnaces commonly used for the better grades of coal, but the tests have shown the possibility of designing suitable furnaces for burning it profitably.

The tests were conducted by the Technologic Branch of the Geological Survey, which is now a part of the Bureau of Mines. The authors of the bulletin are D. T. Randall and Henry Kreisinger. The bulletin will be of interest to fuel engineers, especially to those located in lignite territory. It may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

THIRD ANNUAL MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The third annual meeting of the American Institute of Chemical Engineers was held in New York city, Dec. 7-10, the average attendance at the meeting being 30 to 40. The first session of the meeting was largely devoted to committee reports and to the discussion of chemical engineering education. One of the committee reports, which was adopted, provided for the incorporation of the society under the laws of the state of New York. Another committee report recommended the establishment of a medal of the Institute to be awarded each year to members and non-members for the best paper on applied chemistry. In connection with the committee reports one of much interest was the report of a special committee on the results of a canvass of the members to obtain views on the sort of course that should be given in a college or technical school so that men could be turned out prepared for undertaking the management of chemical works or for developing processes on a commercial and industrial scale. The second and fourth days, and the afternoons of the other two days, were given up to excursions to industrial plants in the vicinity of New York city of especial interest to chemists and managers of chemical works. Among the plants visited were the Marx-Rawalle Glycerine Refinery, in Brooklyn, the Standard Oil Refining Works at Bayonne, N. J., and Blissville, L. I., and the Richmond Borough Garbage Destructor, West New Brighton, S. I. Among the papers presented at the meeting were the following: Dr. F. W. Atkinson, Brooklyn, N. Y.: "The Development of the Chemist as an Engineer"; Prof. M. C. Whitaker, New York: "The Training of Chemical Engineers which Meets the Requirements of Manufacturers"; Dr. C. F. McKenna, Brooklyn, N. Y.: "The Evolution of Portland Cement Processes"; Richard K. Meade, Allentown, Pa.: "The Manufacture of Hydrated Lime"; H. S. Renaud, New York city: "Manufacture of Lignite Briquettes"; David Wesson, New York city: "Blending Oils with Fuller's Earth"; Jerome Alexander, New York city: "The Fitzgibbons Boiler." The following officers were elected: President, Dr. F. W. Frerich, Herf & Frerich Chemical Co., St. Louis; Vice-Presidents, Mr. G. P. Adamson, Baker & Adamson Chemical Co., Easton, Pa.; Mr. Eugene Haanel, Department of Mines, Ottawa, Ont., and Mr. L. H. Baekeland, Research Chemist, Yonkers, N. Y.; Secretary, Mr. J. C. Olsen, Brooklyn Polytechnic Institute; Treasurer, Mr. H. S. Renaud, Waller & Renaud, New York city

RECENT PATENTS.

The following patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of patents, McGill Bldg., Washington, D. C.

971,564. Flux for Protecting a *Bath of Copper or Brass.* Walter S. Rockey and Hilliary Eldridge, New York, N. Y. Patented October 4, 1910.

971,611. Art of *Enameling* Metals. George L. Rice and Benj. W. Gilchrist, Woodhaven, N. Y.; said Gilchrist assignor to said Rice. The method consists in depositing, by electrolytic process, on the article to be enameled, a coating of magnetic material and sulphur, and then applying the enamel thereto. Pat. Oct. 4, 1910.

971,669. *Alloy* and Method of Making Same. Louis C. Dodd, Buffalo, N. Y. Pat. Oct. 4, 1910.

971,830. Manufacture of *Fertilizer.* Leonard Roberts Coates, Baltimore, Md. Pat. Oct. 4, 1910.

972,030. Manufacture of *India-Rubber* and Apparatus Therefor. Harry Sidney Smith, Caledonia, Tobago, British West Indies. Pat. Oct. 4, 1910.

972,079. Method of *Autogenous Welding,* Cutting, or Soldering Metals. Berthold Hoffman, Grisheim, Germany, assignor to Chemische Frabrik Griesheim-Elektron, Frankford-on-the-Main, Germany, a corporation of Germany. The method consists in supplying the burner with ethane as the principal combustion agent. Pat. Oct. 4, 1910.

972,130. *Pigment-Color.* Frederick Runkle, Elberfield and Martin Hersberg, Opladen near Elberfield, Germany, assignors to Farbenfabriken vorm. Friedr. Bayer & Co., Elberfield, Germany. Pat. Oct. 4, 1910.

972,149. Method of Treating *Ores.* Charles E. Baker, Chicago, Ill. Pat. Oct. 11, 1910.

972,345. Preparation of a Fat-Like Substance from the Bodies of *Bacteria.* Geo. Deycke, Constantinople, Turkey, assignor to the firm of Kalle & Company, Aktiengesellschaft, Biebrich, Germany. Pat. Oct. 11, 1910.

972,352. Treatment of *Coke.* Benjamin Ely and Arthur Rollason, Pye Bridge, England. Pat. Oct. 11, 1910.

972,403. Process for Obtaining *Textile Fibers.* Joseph Eduard Pfiel, Vienna, Austria-Hungary. Pat. Oct. 11, 1910.

972,518. *Tanning Compound.* John M. Dill, Artesia, N. Mex. Pat. Oct. 11, 1910.

972,561. Method of and Apparatus for Producing *Coated Metal Objects.* John F. Monnot, New York, N. Y., assignor to Duplex Metals Co., New York, N. Y., a corporation of New York. This method comprises heating a metal article to be coated on the hearth of a furnace and under cover of a bath of fused protective material, connecting to such furnace a mold and allowing same to give with such protective material and then passing said object into said mold and displacing a portion of the protective material in the mold back into said furnace, disconnecting the mold from the furnace and casting molten metal into the mold and into contact with the surface of said object, and permitting such molten metal to solidify against such surface. Pat. Oct. 11, 1910.

972,567. *Fertilizer* and Process for Making the Same. Spencer B. Newberry, Baybridge, Ohio, assignor of one-half to Geo. R. Fishburne, Charleston, S. C. Pat. Oct. 11, 1910.

HELP WANTED—Four chemists, recent graduates, $45.00-$60.00 per month. The Engineering Agency, Inc., 16th floor, Monadnock Block, Chicago.

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